SUMMARY REPORT

OF THE

GEOLOGICAL SURVEY BRANCH

OF THE

DEPARTMENT OF MINES

FOR THE CALENDAR YEAR

1910

PRINTED BY ORDER OF PARLIAMENT

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EXCELLENT MAJESTY
1911

To His Excellency the Right Honourable Sir Albert Henry George, Earl Grey, Viscount Howick, Baron Grey of Howick, a Baronet, G.C.M.G., &c., &c., &c., Governor General of Canada.

MAY IT PLEASE YOUR EXCELLENCY,—

The undersigned has the honour to lay before Your Excellency, in compliance with 6-7 Edward VII, chapter 29, section 18, the Summary Report of the operations of the Geological Survey during the calendar year 1910.

WILLIAM TEMPLEMAN,
Minister of Mines.

To the Hon. William Templeman, M.P.,
Minister of Mines,
Ottawa.

Sir,—I have the honour to transmit, herewith, my summary report of the operations of the Geological Survey for the calendar year 1910: which includes the reports of the various officials on the work accomplished by them.

I have the honour to be, Sir,
Your obedient servant,

(Signed) R. W. BROCK,
Director Geological Survey.

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DEPARTMENT OF MINES

FOR THE CALENDAR YEAR 1910.

To the Hon. William Templeman, M.P.
Minister of Mines.

Sir,—I have the honour to submit herewith, a summary report on the operations of the Geological Survey for the calendar year 1910.

Several changes in the personnel of the Survey took place during the year. Messrs. J. F. E. Johnston, O. O'Sullivan, and F. O'Farrell, draughtsmen, resigned. The following appointments were made:—

Dr. P. E. Raymond, as invertebrate palæontologist; Dr. Edward Sapir, as anthropologist in charge of the Division of Anthropology; Mr. Stanley G. Alexander, as draughtsman; Miss C. A. Macdonald, as stenographer.

The present organization of the Survey is as under:—

Administrative and General.—Director, secretary, resident caretaker, 3 stenographers, 2 publication clerks, messenger, night-watchman, 3 fire-watchmen, cabinet-maker and carpenter.

Geological Division.—11 geologists, 6 assistant geologists, 1 compiler.

Palæontological Division.—1 vertebrate palæontologist, 2 invertebrate palæontologists, 1 assistant palæontolgist.

Mineralogical Division.—Mineralogist and curator, assistant curator, collector and distributer.

Topographical Division.—Topographer, 3 assistant topographers, custodian of instruments.

Draughting Division.—Geographer and chief draughtsman, 9 draughtsmen, clerk.

Photographic Division.—Assistant photographer.

Natural History Division.—Botanist and naturalist, assistant botanist and naturalist, stenographer, preparator, taxidermist.

Anthropological division.—Anthropologist.

Library.—Librarian, assistant.

As a consequence of the rapid development of Canada the work devolving upon the Survey has vastly increased, and the staff is numerically unable to successfully cope with it. A large increase is, therefore, necessary. Lack of accommodation in the old Sussex street building, occupied by the Survey, prevented additional appointments. Now that the Victoria Memorial Museum with its increased room and facilities is being occupied, every effort will be made to strengthen the staff, particularly in the divisions that are relatively weakest.

While the Survey is being liberally provided with funds for its work, in one respect it is suffering—the salaries paid to technical officers are too low. A marked improvement has been made in this regard during the past three years, but more will have to be done if the Survey is to attract and retain the type of man that is needed to secure good results. The work is such that anything short of the best is worse than none at all. Hence the first requirement is the man; the facilities for work are of only secondary importance. When the Survey has secured the right man, it should be in a position to retain his services. To do this it is not necessary to compete in salary with private corporations. The officials are willing to remain with the Survey at salaries greatly less than they could secure from business corporations; all that is required is a salary sufficient to enable the official to live without financial worry, and to properly educate his children. The initial salary into Division II A is sufficient to attract the class of young men required, i.e. students who have taken their Ph.D. degrees in geology, but to retain them it is necessary to promote them into Division I B, when they have established a reputation for good work. They can not be expected to wait for the flux of time and the annual increase to place them there. Similarly, promotion from Division I B to Division I A must be made when the official has taken a front rank in his profession.

To secure a mature geologist who has had a wide experience, and has demonstrated by his work the possession of first rate ability, it would be necessary to appoint him in Division I A. While some of our own capable officials are still in Division I B, this seems unfair, hence to secure a qualified staff, the only recourse is the slow process of training men—with a prospect of losing them when they become efficient.

COMMITTEES.

The Geological Committee, consisting of Messrs. McConnell, McInnes, LeRoy, and Young (Secretary), and the Map Committee, consisting of Messrs. Dowling, Senecal, Boyd, and Dickison (Secretary), have rendered excellent service in connexion with reports and maps. A great deal of important work falls upon the members of these committees, especially upon the secretaries, demanding much time, and for which individual credit cannot be given. Marked improvements in reports and maps have been made by the committees, and improved standards have been fixed. Encouraged by the success of these committees, a Library Committtee has been formed, and a Museum Committee, consisting of officials responsible for the various divisions of the Museum, will be organized.

FIELD WORK.

The geological and topographical field work undertaken by the Geological Survey during the past season has, as usual, been economic in its bearing, most of it directly

so; but a little has been on the broader problems of Canadian geology whose solution is required for the interpretation of the facts gleaned in the detailed examination of the mining districts. Most of the fields selected are those in which work has been specially asked for by the mining profession, Boards of Trade, etc. Not all such requests received could be met, on account of the lack of specially qualified men to take charge of the operations. So far as possible, however, this was done. The guiding principle in the selection was to choose those districts in which the work would be likely to prove of most immediate or of greatest value. The parties were distributed as follows:—

Mr. D. D. Cairnes was engaged in investigating the ore deposits of the Atlin district, B.C. This district has for a decade been known as a placer field. During the past season some promising developments in lode mining have taken place.

Mr. R. G. McConnell spent the season studying the geology and ore deposits of the Stewart district at the head of Portland canal, B.C. This district atttracted a great deal of attention during the summer. While promising deposits have been found, exaggerated reports sent out threatened a wild boom, which, fortunately, the Survey was able to assist in preventing, by the publication of official despatches from its representative in this field.

Mr. G. S. Malloch made a topographical survey of this district.

Mr. W. W. Leach continued his topographical and geological mapping of the Hazelton district, B.C. The approach of the Grand Trunk Pacific railway brings this section into prominence. Promising discoveries of silver-lead, copper, and coal have beeen made.

Mr. R. H. Chapman, assisted by Messrs. Chipman, McLean, MacKay, McElhanney, and Wookey continued the topographical mapping of Vancouver island. Mr. McLean continued the triangulation of the island as control for the topographic maps. Mr. Chapman divided his forces into three parties and completed the mapping of three sheets.

Mr. C. H. Clapp made a detailed examination of the area of the Victoria and Saanich sheets, which were topographically mapped the previous season by Mr. Chapman. Vancouver island is now atttracting many setttlers and the topographical and geological mapping of the island is of great and immediate value.

Mr. C. H. Camsell completed his topographical and geological survey of the Tulameen district, B.C., and made a reconnaissance from the International Boundary line to the Nicola valley. This section is noted for the variety of its minerals, and prospect of railway transportation is bringing it into notice.

Mr. L. Reinecke completed his topographical mapping of the Beaverdell mining district, West Fork of the Kettle river, and began a study of its geology and ore deposits.

Mr. W. H. Boyd made a topographical survey of the Deadwood Mining Camp and continued his survey of the Slocan district.

Mr. O. E. LeRoy made a study of the geology and ore deposits of Deadwood, completed his investigation of the ore deposits of the Slocan silver-lead district, and made a preliminary examination of Franklin Camp, North Fork of the Kettle river.

Mr. S. J. Schofield continued his topographical and geological survey of East Kootenay.

For the correlation of the formations met with in the mining camps, and for the deciphering of their complicated geological structure, several detailed geological sections across the Cordillera in Canada are required. Such a section has been constructed by Mr. R. A. Daly, along the International Boundary line. A similar section is now needed along the main line of the Canadian Pacific railway. Work upon this was commenced the past season.

Mr. J. A. Allan was engaged in the vicinity of Ice river.

Mr. H. S. Shimer studied in detail the Devono-Carboniferous rocks near Banff.

The Cambrian rocks near Field have been made the subject of careful study, for several seasons, by Dr. C. H. Walcott, Secretary of the Smithsonian Institution, Washington. Incidentally, it may be mentioned that Dr. Walcott found here one of the most remarkable deposits of fossils ever discovered.

Mr. D. B. Dowling continued his exploration of the coal-bearing rocks on the east slope of the Rockies. This year he was delimiting the coal formations in the neighbourhood of Jasper park, Yellowhead pass. Being on the Grand Trunk Pacific railway these fields are of special importance.

With settlement of the country the demand for clays suitable for all kinds of clay products becomes urgent. If found, important industries are developed; without them, a serious burden is imposed upon the communities. Mr. Heinrich Ries, of Cornell University, who last year reported on the clays of the Maritime Provinces for the Survey, and Mr. Joseph Keele, spent the season investigating the clay resources of the western provinces.

Mr. W. McInnes mapped and more accurately defined the geological boundaries in the district north of Cumberland House and The Pas, work which is at present desirable in anticipation of the early construction of the Hudson Bay railway.

Mr. J. D. Trueman spent the season in the Gunflint Lake district, western Ontario. This area has never been mapped geologically, and on account of its proximity to known iron districts its examination was called for.

Mr. W. H. Collins completed his geological map of the Gowganda district, and commenced the mapping of the unsurveyed but promising district west of the Timiskaming and north of the Sudbury sheets.

Mr. W. A. Johnston continued his topographical and geological surveys in the Lake Simcoe district.

Mr. C. R. Stauffer began a resurvey of the geology of southwestern Ontario in which important non-metallic mineral deposits occur. No detailed study of its geology has been made since the early days of the Survey, the reports and maps of which are long since out of print. Quarries, wells, borings, etc., have brought to light much additional information, so that a revision of the geology of this district will be welcomed.

Mr. Morley E. Wilson was engaged in mapping and examining the district east of Abitibi lake. This district is similar to northern Ontario and it is hoped that similar mineral discoveries may be made in it.

Mr. J. A. Dresser continued his investigations into the economic geology of the Eastern Townships of Quebec.

Mr. J. W. Goldthwait studied the raised marine beaches south of the St. Lawrence river. This work has a bearing on the clays, sands, and soils of the region. The elevation of the land relative to the gulf has been comparatively recent; it is important to ascertain if it has been uniform or greater at one point than another, and also, if possible, whether the uplift is still in progress.

Mr. G. A. Young made a geological and topographical survey of the Topique district, New Brunswick. For some years this field has been brought to the attention of the Survey, there being a strong feeling in New Brunswick that it may prove to be possessed of mineral wealth.

Mr. M. Y. Williams made a detailed study of the district about Arisaig, N.S. This presents probably the best section of Silurian rocks in eastern America, and their detailed study here, it is hoped, may lessen the difficulties of investigation in other localities in which this formation occurs.

Mr. E. R. Faribault continued his mapping of Nova Scotia and his investigation of the gold-tungsten bearing rocks. Leaving his party at work in the field, Mr. Faribault spent the two mid-summer months in the Chibougamau district, Quebec, as one of the commissioners appointed by the Quebec Government to report on the geology and mineral resources of the Chibougamau Lake district, his services having been loaned by the Survey to the Quebec Government for this purpose.

Mr. W. J. Wilson spent a few weeks in the Maritime Provinces collecting fossils to aid in fixing geological horizons, and Mr. P. E. Raymond collected in the neighbourhood of Ottawa, with a similar object.

No detailed work was done by the Survey in Porcupine, as this district was receiving attention at the hands of the Provincial Bureau of Mines of Ontario. By mutual arrangement, duplication of work is avoided.

IMPORTANT MINERAL DISCOVERIES AND DEVELOPMENT DURING THE YEAR.

In the reports of the field officers which follow will be found particulars of interest regarding new mineral discoveries and developments during the year. Among the more important are the following:—

The encouraging developments following prospecting for lodes in the Atlin district, reported upon by Mr. Cairnes.

The Portland Canal and Stewart district, studied by Mr. McConnell.

The promising silver-lead prospects in the Hazelton district reported on by Mr. Leach.

The discovery of diamonds in peridotite from Olivine mountain in the Tulameen district, southern British Columbia, where Mr. Camsell has been at work. While of scientific interest rather than of commercial importance, it will be worth the pros-

pector's while to be on the lookout for diamonds in the gravels of streams draining areas of these basic igneous rocks. Such areas are not uncommon in British Columbia. Similar basic rocks are also known in Ontario and Quebec. Commercial diamonds of the first quality have been found in the glacial drift in Illinois, Ohio, and other States. As this drift material has come from northern Ontario and Quebec it is presumed that the source of the diamonds is somewhere in this northern section also. The only known original matrix of the diamond is a peridotite or closely related rock, so that, while diamonds are perhaps not confined to such rocks, so far as present knowledge goes they are the most promising ones to prospect for these gems.

The Tulameen peridotite also carries gold and platinum.

A sample of peridotite and an included vein from the Johnny Bull claim, Trout creek, about 10 miles from Summerland, Okanagan lake, assayed for the Survey by the Mines Branch for platinum, yielded positive results.

The silver-lead district of the Slocan examined by Mr. LeRoy was at one time the leading silver-lead camp of Canada. Some important discoveries were made there during the past year and it affords a promising field for further development.

On the Grand Trunk Pacific, in the neighbourhood of Jasper park, where Mr. Dowling was engaged during the past season, coal seams have been opened.

Messrs. Ries and Keele have found some good fireclays during their examination of the clays of the western provinces.

Lignites have beeen found in well digging and borings at several points on the plains where domestic fuel is badly needed.

In Ontario the most important development has been in the Porcupine gold district which was visited by the writer. Its geological study and mapping was undertaken by the Ontario Bureau of Mines. Farther north, at Grand Rapids on the Mattagami river, iron ore, reported to the Survey in 1877-78 by R. Bell, was receiving some attention and was also under investigation during the past season by the Ontario Bureau of Mines.

The work by Mr. Dresser in the Eastern Townships of Quebec shows that expansion is possible in the non-metallic mineral industries.

Near Moncton, N.B., a gas field has been tapped. It was visited in March by the writer, but since then new wells have greatly increased the production. A little oil has also been encountered with the gas. This field gives promise of becoming important.

The examination of the clay samples which Messrs. Ries and Keele collected in the Maritime Provinces last year has shown that very valuable clays similar to those of New Jersey occur in New Brunswick and Nova Scotia.

Mr. Faribault reports that the development of the tungsten deposits, so far as it has gone, indicates that these are of commercial importance.

TOPOGRAPHICAL DIVISION.

During the past year considerable progress has been made in the organization of the topographical division. To this the generous assistance of the United States Geological Survey, afforded through Mr. R. H. Chapman, contributed in no small degree. A corps of carefully selected topographers is being trained, and our standard

topographical maps, now being made. will compare favourably with those produced anywhere. Perhaps no part of the work of the Geological Survey is of more immediate economic value. For not only are these accurate topographical maps necessary as base maps for the detailed geology of mining camps, to make it sufficiently exact for economic purposes, but they are in themselves very valuable to the mining and other engineers, since they may be used in many of the engineering problems which are constantly arising, thereby saving for developing and other directly productive uses large sums which would otherwise be required for private surveys.

NATURAL HISTORY DIVISION.

In addition to geological work, the Geological Survey is called upon by the Department of Mines Act to engage upon work in natural history, anthropology, etc.

Mr. John Macoun spent the field season in Nova Scotia collecting information and material illustrative of the botany of the Province. He also supervised the work of Mr. C. H. Young, who was collecting marine fauna on the Nova Scotia coast.

Mr. James Macoun went to the northwest coast of Hudson bay to collect the flora and fauna of that district.

ANTHROPOLOGICAL DIVISION.

While the Survey has done some important work in anthropology in the past, it has been spasmodic and entirely secondary. With the rapid settlement of the country, the time has come when work along this line must be vigorously prosecuted, for settlement destroys the materials, and unless they are collected and preserved now they will be lost forever, and the succeeding generations of Canadians will search in vain for authentic information concerning the native races of their country.

Since this work was called for in the organic law of the Department and the time was opportune, a Division of Anthropology was established this year and Dr. Edward Sapir appointed to take charge of it. The plans of the Anthropological Division include field work among the native tribes of Canada for the purpose of collecting extensive and reliable information on their ethnology and linguistics, archæological field work, the publication of results obtained in these investigations, and the exhibition in the Museum of specimens illustrative of Indian and Eskimo life, habit, and thought.

Mr. Sapir spent the field season in the west, more particularly in the neighbourhood of Alberni, Vancouver island, studying the Indians of this section.

Mr. C. Stefansson, who is in the Arctic under the joint auspices of the American Museum of Natural History and the Geological Survey, continued his study of the life and habits of the Eskimo east of the Mackenzie river. He had a trying winter, on account of the failure of the hunt, but managed to withstand the hardships. The last year he expected to spend near Coronation gulf.

PUBLICATIONS.

The results of the investigations of the Survey are given to the public in the form of maps and reports. Since, however, a great many different classes and individuals find the work of the Survey of interest and value for very different purposes, it is impossible in a general report to present the matter in the form and in the

detail that might be desirable for any single class or individual. A great deal of information is acquired that may be of value to particular persons but not to the general public, hence must be omitted in a report. Much of such information is given to individuals in the field, and this is perhaps the most valuable service rendered by the Survey. A great deal is supplied by correspondence. This branch of the Survey's work is growing rapidly. To avoid delay, information that is of immediate interest to the public is furnished through press bulletins, which are sent to the press throughout Canada and also to those individuals who have expressed a wish to have their names placed on the "Notice list" of the Survey. Timely information concerning the Porcupine gold district, the Stewart district, Portland canal, the Atlin district, Hazelton district, etc., was made public in this manner.

During the year 30,325 publications were distributed to libraries and to individual applicants. Of these 18.852 were distributed in Canada, 3,282 in the United States, 1,225 in Great Britain, and 6,966 in other countries. The sale of publications amounted to $461.44.

A list of the maps and reports published during the year will be found near the end of this report.

Attention is called to the fact that maps recently published by the Survey may be obtained printed on linen. For field use, or hard service, the linen maps are very serviceable, being unaffected by moisture and practically indestructible. An extra charge of ten cents is made to cover the cost of the material.

PHOTOGRAPHIC DIVISION.

Up to the present the work of the photographic division has been confined almost exclusively to developing and printing negatives obtained by officials in the course of their field work, and to photographing specimens for illustrating reports. Blue-printing and some map reducing and enlarging have been done in the draughting division. A great economy of time and money may be effected by equipping a photographic laboratory for process work, as this may take the place of handwork by draughtsmen, thereby releasing them for productive work. Provision is being made for this in the new photographic laboratory, and it is expected that it will result in less delay in the publication of our maps.

Much of the topographic mapping is done by a photographic method, and a large part of the work of the photographic division is the developing and enlarging of the negatives obtained. for the use of the topographers in the compilation of their maps.

During the year over 1,200 topographic negatives were developed and over 1,000 enlarged prints made. About the same number of ordinary negatives were developed and over 4,000 prints made from them.

The negatives in the possession of the Survey acquired during the past forty years of field work in all parts of the Dominion form a very valuable collection, illustrating the physical features, geology, timber and other resources of the greater part of Canada. These are being catalogued as occasion permits, so that they may be readily accessible for use.

EDUCATIONAL WORK.

By a little extra effort and at a comparatively small expenditure the Survey is able to materially assist technical education in the educational institutions of the country. Reports and maps that may be of use in the higher grade schools and colleges are supplied free of cost. To institutions of at least high school grade, attractive cabinets of typical Canadian rocks, minerals, and ores are also furnished free. Positions as student assistants on field parties are reserved for college graduates or students who have finished at least their second year, and who are specializing in geology, mining, or topography. The experience gained in the field supplements the college work and is of great and direct educational value.

VICTORIA MEMORIAL MUSEUM.

For many years museum halls and storage accommodation in the old building have been taxed to their utmost capacity and as a natural result little has been possible in the way of new acquisitions. During the past year, however, some important collections were obtained and preparations made for moving the collections to the new Victoria Memorial Museum. Although the building was not completed and is still in the contractor's hands, moving was begun in November, and at the close of the year the greater part of the offices and collections had been placed in the new building, where the valuable material will no longer be in danger of destruction from fire. On account of lack of accommodation in the old building, not only was the Museum stifled, but the general work of the Survey was seriously handicapped. These disabilities are removed in the new quarters. The Museum can now expand and the work of the Survey be accelerated. The Museum will include the illustrative material acquired by the various divisions of the Survey, namely, mineralogy and geology, biology, and anthropology. It will, therefore, be a complete natural history museum. In the old Museum, mineralogy and geology were dominant, the other divisions being only sparingly represented. It is the intention to increase the economic material in the mineralogy and geology division so that Canadian ores and their products, their mode of occurrence, etc., may be thoroughly represented, and to greatly strengthen the biological and anthropological divisions. A large amount of material suitable for public display is already on hand, which for lack of room could not be placed in the old exhibition halls. For the present it is the intention to restrict the Museum to Canadian material (except in educational collections where necessary objects may be lacking in Canada) in order to make it, first of all, the great Canadian Museum, whose collections in Canadian material will surpass all others. When this has been accomplished in all divisions it may be advisable to enlarge its scope, and make it a world museum. It is proposed to utilize some space for scientific collections. As a National Museum it is the natural repository for all Canadian objects of scientific value. Much of such material is of no interest to the general public, and, therefore, should not take up valuable space in the exhibition halls, but should be so arranged, catalogued, and stored as to be accessible to Canadian students and scientists from abroad who may wish to study Canadian material. It will be some time before the exhibition halls can be made ready for the public. The old furnishings are unsuit-

able, and new modern cases will be provided. The specimens for public display will each have to be selected, labelled, and placed in position. This involves an immense amount of labour that has to be done personally by the officials in charge as it cannot be relegated to temporary helpers. In the old building, on account of lack of space, little could be done in this direction. Now that the material is in the new building this work will be pushed.

INTERNATIONAL GEOLOGICAL CONGRESS.

At the instance of the Geological Survey, the Government of Canada and the Canadian Mining Institute invited the International Geological Congress to hold its next meeting in Canada. This invitation has been accepted and in 1913 about one thousand of the leading geologists, representing every civilized country, will visit Canada and study the geology and mineral resources of this country.

WORK OF THE DIRECTOR.

Summary.

Routine work occupied the greater portion of the year. In January, the American Museum of Natural History, New York, was visited, also the Carnegie Museum, at Pittsburgh. In March, the meeting of the Canadian Mining Institute in Toronto was attended as were meetings of council throughout the year. The meeting of the Nova Scotia Mining Institute was also attended. Returning from the latter the property of the Maritime Oldfields Company, near Moncton, was visited. In May, I accompanied the Hon. Wm. Templeman to Washington, Philadelphia, and New York, to visit the United States Geological Survey, the Smithsonian Institution and United States National Museum, the Museum of the University of Pennsylvania, Philadelphia, and the American Museum of Natural History, New York. As a result of the information obtained it was decided to equip the New Victoria Memorial Museum on the lines now being followed by the American Museum of Natural History.

Notes on Field Work.

In June, a few days were spent in the Porcupine district.

In July, a day was spent at Kazabazua, Que., investigating a rumoured discovery of gold ore, 1½ miles from Danford Lake post-office. A 30 foot pegmatite dyke in crystalline limestone was found to be the discovery. It is coarse, the quartz occurring in masses up to 10 feet in diameter. Feldspar, including some plagioclase, coarse hornblende, pyrite, graphite, and sphene are the associated minerals. Such pegmatites might in places afford commercial feldspar. Some mica deposits occur in this district.

August and part of September were occupied on the Hudson Bay trip of His Excellency Earl Grey.

During the latter part of September I went to Los Angeles to represent Canada at the meeting of the American Mining Congress. A week was spent examining the oil field of California. From California I came north to examine, in company with Mr. John Sterling, Inspector of Mines of Alberta, into the condition of Turtle mountain.

Gas near Moncton, N.B.

The Maritime Oldfields, Ltd., of Moncton, have been boring for oil and gas, west of the Petitcodiac river, 10 miles south of Moncton, and about 5 miles north of Hillsborough. At the time of my visit, March 18, several wells were completed and new holes were being started. Well No. 3 had passed through three groups of oil and gas sands and at 1,725 feet was stopped on account of salt water being encountered. This had been shut off and the well was pumping about two barrels of oil per day and had a rock pressure of gas of about 100 pounds. It was estimated to flow about 1,000,000 feet per day.

Well No. 5, drilled to 1,407 feet, also passed through three groups of sands, and was yielding a little less oil but more gas than No. 3. The oil was a thick green petroleum and was being supplied to the Intercolonial railway at Moncton.

Since the time of visit boring has been vigorously prosecuted, and it is now reported that the Company has ten wells with an estimated flow of gas of about 39,000,000 cubic feet per day (estimated by rise in pressure in the first minute), and a yield of oil of about 25 barrels per day. Two new wells are about ready to produce, and others are being started.

The deepest well is 2,175 feet. The rock pressure of the gas is given as varying in the different wells from 30 pounds to 610 pounds.

It is proposed to supply the town of Moncton with gas from this field.

Porcupine District, Ontario.

This district will be found described in detail in the report of the Bureau of Mines, Ontario. It will be sufficient in this place to quote a few sentences from the press bulletin issued by the Geological Survey in June last.

"Most of the gold occurrences so far located are in the township of Tisdale, but some of the properties are in Whitney, Mountjoy, Ogden, Deloro, and Shaw. A new discovery has just been announced from Kamiskotia lake, west of the Mattagami river. Then, of course, there are the older discoveries at Nighthawk lake. The prevailing rocks are greenstones (including old diabases), quartz-porphyries, and schist, presumably of Keewatin age, with some slates, greywackes, and conglomerates, probably Huronian. The quartz seems to occur in any of the rocks and in all manner of forms. There are some well-defined veins, there are some large apparently isolated masses of it, the so-called 'domes,' and there are numerous irregular quartz stringers, which may swell out in places to large masses, that may or may not have a vertical extension. The majority of the veins and zones of quartz stringers seen had a strike approximately northeast, while that of the rocks was more nearly east—that is they were distinctly cutting across the strike or schistosity of the rocks, as the case might be. A few had a strike of a little south of east. The quartz holds many inclusions of more or less altered country rock. Pyrite is rather extensively developed in and along these inclusions. The gold, which is often coarse, is distributed in much the same way as the pyrite, with which it is usually rather closely associated, but some may be found in the pure quartz. A little galena, blende, and chalcopyrite may also be present. A ferruginous carbonate, probably ankerite or

siderite, is, next to quartz, the most abundant gangue mineral. It weathers deeply to reddish-yellow iron oxide. Calcite, chlorite, talc, probably sericite, and feldspar were also noticed.

"Porcupine is fortunate in having had a number of strong interests take hold in the initial stages of the camp, which ensures intelligent development and a thorough test of some of the more promising prospects. Plants were brought in during the winter, and a surprising number of properties are equipped with power plants.

"The 'show' properties at present are the Timmons, Dome, and Foster.

"The Timmons (Hollinger) is about seven miles west of Porcupine lake and a mile and a half east of the Mattagami river. A clearing of forty acres has been made and substantial mine buildings erected. The plant consists of two boilers, a compressor, hoist, and dynamo; a crusher and small prospecting stamp mill are being erected. The buildings are lighted with electricity, and supplied with hot and cold water, baths, etc. A number of veins are exposed. On the largest, with a maximum width of about 20 feet, three shafts have been sunk, the distance between the first and last being about 800 feet. For the greater part of this distance, vein is exposed. The deepest shaft is about 90 feet, and is in a 12 foot vein at the bottom. Sinking is being continued. Beautiful ore, carrying free gold, is obtained at the bottom of the shaft, and over the surface showings gold splashes are liberally scattered. About 800 tons of very promising ore is on the dump, from which almost anywhere showy specimens might be obtained. Several lots of ore from the dump, sent out for sampling, are said to have yielded high results. The fresh ore is very promising looking and seems quite as good at 90 feet as on the surface. A number of other veins have been stripped, one of which has been traced about 300 feet, and shows gold at various points.

"The Dome is also under vigorous development. Here two large masses of quartz, 60 feet or so in width and of considerable length, are opened up. Coarse gold adorns the surface of the quartz at a number of points, and the systematic sampling of the quartz is said to yield very satisfactory results. Several shafts have been sunk and diamond drilling is now to be undertaken to determine the conditions at depth. A small test mill is being erected, and the property is well equipped with a good plant and buildings.

"The Foster vein is a belt or vein of the iron carbonate filled with transverse masses and veins of quartz. The quartz contains many inclusions of the carbonate in which sulphides and gold have been deposited. This vein or belt has been traced by trenching and stripping at intervals for nearly half a mile, and has a width, where exposed on the Foster, of from 6 to 20 feet. Fine showings of gold occur, and the clean-cut character and extensive horizontal dimensions of the lode suggest that it may have an equally strong vertical extension.

"From the above it will be seen that there are some grounds for the hopefulness regarding the future of this new camp. Of course there are properties here which will furnish specimens but never anything more, and many that will not do even this. There are some that will be 'teasers,' with just enough quartz with values to attract money for their development; but not enough in one place, or not enough continuity to the bodies to be exploited profitably. But there are some really promising pros-

pects, which, even if they should not prove altogether satisfactory with depth, yet may, on their present showings, have quite a tidy output of gold.

"The development during the next few months, which will furnish some clue as to the deeper conditions, will be followed with much interest. The history of gold mining in Ontario has not been highly encouraging; but it is to be remembered that gold mining in Ontario is to-day in exactly the same position as was silver mining seven years ago, and the chances of finding a notable gold camp are to-day quite as good as were the chances of locating a Cobalt at that time.

"Porcupine is as yet in the prospect stage. But it has some of the essential qualities of a gold camp, sufficient to have induced experienced mining men to take up options at high figures, and to undertake large expenditures to determine if it possesses all the essential factors."

Since the above was written, development has proceeded steadily, with such satisfactory results that several of the companies are erecting large mills to handle their ores. The Ontario Government is building a railway into the camp from the Timiskaming and Northern Ontario railway, at Kelso. It is expected to be in operation in July.

Turtle Mountain, Frank, Alta.

Since the great landslide at Frank in 1903 the Survey has kept Turtle mountain under inspection, as the northwest shoulder overlooks the town in a threatening manner. On October 12, with Mr. W. H. Boyd, of the Survey, I again visited Frank. In this examination we were accompanied by Mr. John P. Sterling, Provincial Inspector of Mines, and three representatives of the coal company whose property lies along the base of the mountain.

We found the northwest shoulder to be in a more threatening condition than it was last year. Until last year it exhibited no signs of movement nor, apart from its structure, of any weakness. Last year, however, two small cracks were detected, but so slight that their existence might have been questioned. This year they were quite marked. The cracks between the shoulder and the peak also show development. In most cases the block severed by a crack is not large enough to cause damage, but as the joint planes along which the cracks form dip towards the face of the cliff, only those near the face can open, the weight of the inverted wedge tending to keep the joint closed. Moreover, the surface is covered with shingle so that only a gaping crack makes itself visible, hence a dangerous break back from the face of the cliff along which an enormous slide might take place, might not be detectable on the surface even at the time a slide was about to occur.

The cracks on the north shoulder are significant as indicating that movement has taken place and that the solidity of this huge mass of rock is not to be relied upon. The recent movements indicated by these cracks may well be ascribed to the disturbing effects of mining operations.

In view of what has already occurred, of the present condition of Turtle mountain, and of the damage to property and life that would result in case the northwest peak and shoulder fell, it does not appear safe to take further liberties with this mountain and in my opinion the coal seams near its base should not be disturbed.

The Hudson Bay Route.

OBSERVATIONS MADE IN CONNEXION WITH THE TRIP OF HIS EXCELLENCY THE GOVERNOR GENERAL—EARL GREY—TO HUDSON BAY.

Interest in the country tributary to Hudson bay and in the Hudson Bay route, has been reawakened by the determination to proceed with the construction of the Hudson Bay railway. His Excellency the Governor General—Earl Grey—who has always shown a keen desire to secure first-hand information regarding Canada and its resources, and a lively interest in "the continuous disproof of the theory of the frozen north," which has made up its recent history, undertook last summer to go over the Hudson Bay route with a small party.

His Excellency has extended to the writer, who had the privilege of accompanying him, permission to publish as a Geological Survey report an account of the trip and a description of the districts traversed.

ITINERARY.

On August 3, the party left Winnipeg, and on the 4th embarked at Selkirk on the steamer *Wolverine,* dropped down the Red river and traversed Lake Winnipeg. On the evening of the 5th, a stop was made at the mouth of the Saskatchewan, and on the morning of the 6th, Warren landing, at the outlet of Lake Winnipeg, was reached. The journey from Warren landing to Norway House, about 23 miles, was made by launch. The route lies down the Nelson river into Playgreen lake. From Playgreen lake the Nelson issues in several branches, the two main channels of which reuniting at Cross lake, enclose Ross island, 53 miles long and 21 miles wide. The eastern channel, or Sea river as it is sometimes called, leaves Playgreen lake near the eastern end, in several branches that unite at Little Playgreen lake. Norway House is situated on one of these branches, at the entrance to Little Playgreen lake.

At Norway House, the canoe journey commenced, the route followed being the regular Hudson's Bay Company boat route via the Hayes river to York Factory. Leaving Norway House in the afternoon of August 8, in twelve canoes, manned by Norway House Indians, Little Playgreen lake was crossed and Sea river descended about 10 miles before camping. About 20 miles below Norway House, Sea River falls necessitates a short portage and about 8 miles below the falls the boat route leaves the river and ascends a small tributary from the east, known as the Echimamish river. The dark water of this swampy, marshy stream, is in strong contrast to the bluish white Nelson river. A short distance up, the stream expands into a shallow rush-grown stretch of water known as Hairy lake. Camp was made on the evening of the 9th, on marshy ground at a fork of the stream. Ascending the Echimamish three dams, maintained to render the stream navigable for York boats, were passed and the head of the stream reached at Painted Stone portage. A lift over this rock transferred the canoes to Hayes River water, which is followed to the sea. After a stretch of narrow river and several small lakes, Robinson portage was reached, where camp was pitched on August 10. This portage, about a mile in length, is the only long one on the whole route, and is overcome by a rude tram, provided with several push cars. From Robinson portage, the stream flows through a marshy lake, and enters a narrow, rocky defile. York boats follow the river, but our canoe route left

by a half mile portage eastward, and rejoined the boat channel in Pine lake, a few miles farther down. After a further stretch of river, Windy lake was reached, on the shores of which camp was pitched for the night of the 11th. From Windy lake the river is divided into numerous rapid channels, and several short portages are necessary. In this part of its course, its direction is west of north, at right angles to the general direction. After a few miles of turbulent water, Oxford lake was reached. This lake is a fine body of water about 30 miles long, running northeast. It is irregular in outline and is broken by many islands. Oxford House, situated at the outlet, on a ridge of clay between Oxford and Back lakes, was reached on the night of August 12. Leaving Oxford House on the afternoon of the 13th, we paddled round to Back lake and down the stream, here known as Trout river, to Trout falls. The course of Trout river is southwest. It is a rapid stream with several chutes that have to be portaged; Trout falls, the most important one, has a drop of about 16 feet. The river discharges into Knee lake, a narrow, island-dotted lake about 45 miles long. Camp on August 14 was made on a point about 15 miles from the northeast end of the lake. A stretch of river, about 10 miles in a straight line, known as Jack river, connects Knee lake and Swampy lake. A number of rapids occur, especially on the lower portion of this river. Camp was made near the outlet of Swampy lake. Owing to unfavourable weather, the 16th was spent in camp. On the 17th the journey was resumed through Swampy lake and down the river here known as Hill river. For about 20 miles it is full of islands. Rapids are numerous, some could be run with full loads, some were run in light canoes, and some had to be portaged. Shortly after lunch the "Hill," the only outstanding topographical feature on the route, was passed. Camp was pitched at Rocky Point portage. Although numerous rapids were run, about a dozen portages were made during the day. On August 18, the three remaining portages, White Mud, Borrowick falls, and the Rock were made. From the latter to the sea, a distance of nearly 110 miles, no rapids occur, but the current is swift, so that an up-stream journey would be slow and heavy. From Nelson river to the Rock, the general course of the route had been northeasterly. From the Rock, the river takes a more northerly direction. Favoured by the current, and unimpeded by rapids, progress from the Rock was rapid. Fox river, a tributary from the west, was passed shortly after lunch, and camp was made about 16 miles below it. On the 19th, after three hours' paddling, the Shamattawa branch, a large river from the southeast, was reached; by noon, Penneygutway; and about six o'clock we landed at York Factory. Off York, the party embarked on the Canadian Government steamer *Earl Grey,* and proceeded to Churchill, about 180 miles distant.

From Churchill, the *Earl Grey* traversed the 600 miles across Hudson bay to Hudson straits, passing within sight of Coats and Mansfield islands. A short stop was made at Sagluk bay, on the north shore of Ungava, east of Cape Wolstenholm. The cruise was then continued along the north side of Charles island, along the coast of Baffin island and Resolution island, and across the straits, at their entrance, to Port Burwell, a Moravian Mission on the west side of one of the islands of the peninsula which separates Ungava bay from the Atlantic. Leaving Port Burwell, the steamer rounded the Button islands and ran down the Labrador coast to Newfoundland, Cape Breton and Prince Edward Island, finishing the cruise at Pictou, Nova

Scotia. Stops were made at Okkak and Indian harbour on the Labrador coast, Port Anthony and Bay of Islands in Newfoundland, Sydney on Cape Breton Island, and Charlottetown, Prince Edward Island.

GENERAL CHARACTER OF THE COUNTRY—LAKE WINNIPEG TO HUDSON BAY.

[1] The country from Lake Winnipeg to Hill river is typical Laurentian plateau country, similar to much of northern Ontario and Quebec. Low, rounded, rocky hills of about equal elevation are separated by vales, often occupied by marshes, streams or lakes. The watercourses are countless, and ramifying in a most intricate fashion. Lake succeeds lake, joined by river stretch, tranquil or spilling over rocky ledges from level to level. Along the Nelson river the shores are usually rocky, but rarely exceeding 20 or 30 feet in height, with rushes and willows along the water's edge. The shores of Hairy lake are somewhat bolder, but the Echimamish for most of the way filters through a swamp. From Painted Stone, rock hillocks skirt the river and lakes, reaching a maximum of perhaps 150 feet on the canoe route near Pine lake. Near here the first cut clay bank was noticed. Near Oxford House the shores again become higher, approximating 100 feet. Clay banks also appear. Oxford House is situated on a peninsula of clay about 50 feet high. While some rock is exposed, good soil extends from Oxford lake to Knee lake. Beyond Knee lake the country is low to near the Hill. Here clay banks become continuous, rising gradually in elevation to the Rock. The Hill itself has an elevation of about 400 feet.

The Pre-Cambrian rocks disappear a couple of miles below the Rock, and the country from there to the sea is level and drift-covered. Into this clay the river has cut its channel, forming high banks, steep cut where the river impinges, but shelving on the other side. The banks are about 10 feet high at the Rock, but gradually lower, going down stream, to less than 30 feet at York.

CLIMATE.

The climate of the country in the neighbourhood of Norway House does not differ materially from that of Manitoba. Towards Hudson bay conditions are less favourable. The winters are cold, but generally fine and enjoyable. Every resident spoken to, from Norway House to Newfoundland, expressed a decided opinion that winter was the most enjoyable season. The Hayes river at York on the average freezes about the last week of November, and opens about the middle of May. The summers are bright and warm, without an excess of rain. From the agricultural standpoint, the important temperature is that of June, July, and August, for this is what determines the crops that may or may not be ripened. The long days have a favourable influence, and it is probable that climatic conditions are suitable for ordinary agriculture to about half way between Lake Winnipeg and York.

AGRICULTURAL LAND.

Along the watercourses, rock exposures are more numerous than inland, so that from them a judgment cannot be formed of the amount of land suitable for agricul-

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[1] The route from York Factory to Winnipeg is well described by Sir John Franklin and by Dr. John Richardson in Franklin's "Narrative of a Journey to the Shores of the Polar Sea, 1819-20-21." It is also referred to by Robert Bell, in Part CC, Report of Progress, 1877-78, Geological Survey of Canada.

ture. Along the route followed, only occasional patches were seen, but large areas are known to lie to the north. Soil became more noticeable about Oxford House, increasing in amount until, below the Rock, no rock exposures were seen. In places, artificial drainage would be necessary to render the land fit for agricultural uses. At Norway House, wheat, barley, vegetables, small fruits, cucumbers, melons, etc., have been cultivated. At Oxford House, barley, vegetables, and hay are grown. At York, potatoes and some vegetables have been successfully raised, but the area near Hudson bay, while perhaps suitable for ranching and dairying, is probably outside the limit for ordinary agriculture.

FLORA AND FAUNA.

The whole country from Lake Winnipeg to York is timbered, but as the route followed had been the boat route from York, used for almost a century, for a large part of the entire trade of the northwest, the forests have suffered repeatedly from fires, so that practically all is second growth, and no sizable timber was seen. Where the original forest is preserved, merchantable sizes may be expected in the upper portion of the district, and pulp wood for some distance down, but what with forest fires, muskeg and climatic conditions near the bay, it seems unlikely that the timber of that particular district will prove of great value, except for local purposes. Around the southern end of the bay, conditions, of course, are different, and the forest is of greater economic importance. The trees are principally spruce, poplar, and tamarack; canoe birch disappeared on the lower part of the Hayes.

As might be expected on an old route of travel game was not plentiful. Except that Arctic varieties are found in the northern part, the species do not differ in any essential respect from those of northern Ontario. At York, a polar bear had been shot in the Fort two days before our arrival. The waters are well stocked with fish of marketable varieties. The whitefish of Oxford lake are famous, and are said to excel even those of Lake Winnipeg.

GEOLOGY BETWEEN LAKE WINNIPEG AND YORK.

As the journey was made rapidly, with few stops, only a general idea of the geology could be obtained. Pre-Cambrian rocks, which form the eastern shore of Lake Winnipeg, are exposed all the way to the Rock, and for a few miles beyond. For the rest of the distance to York, no solid rocks are exposed, but it is evident from the loose fragments that it is underlain for the most part by sedimentary rocks of lower Palæozoic age, similar to those exposed on the neighbouring rivers, and which form a basin, fringing the bay, from Churchill to Rupert river, at the southeastern end of James bay.

Overlying the solid rocks, except where removed by subsequent erosion, is a mantle of glacial drift which is overlain, towards the bay, by stratified marine clays or sands.

Keewatin?.

The rocks which are considered as probably Keewatin, consist of various schists—banded quartzose schists, green biotite schists, dark hornblende schists, sericite

[1] The names applied to the rocks in the following descriptions are field names, and would probably have to be altered somewhat upon exact microscopical determination.

schists, rather massive chlorite schists, hornfels, greenstones, including coarse diabase-like rocks often epidotized and with well marked pillow structure, the cracks being sometimes filled with calcite.

Laurentian.

The commonest rocks are grey granites, often passing into gneisses, and holding inclusions, often reaching large dimensions, of a dark gneiss. No contact between these rocks and the supposed Keewatin was seen so that their relationship was not established, but near the contact some cherty bands in the granite-gneiss were observed, which appeared to be inclusions from the Keewatin. At the east side of Hairy lake a mass of anorthosite occurs. Cutting the Keewatin, and the Laurentian rocks above mentioned, is a red granite which sends numerous pegmatite dykes into the older rocks. As no rocks younger than the Laurentian were recognized, its age cannot be exactly fixed, but unless it should be proved post-lower Huronian, it may be included in the Laurentian.

Cutting the Keewatin of Knee lake are dykes of a grey syenite porphyry.

On Painted Rock portage and on Oxford lake dark lamprophyric dykes were observed cutting the grey granite and gneiss.

No conglomerates or other rocks that could be recognized as Huronian were seen at any of the points at which we touched.

Palæozoic.

The Palæozoic rocks were not seen in place, but numerous loose fragments, some containing fossils, are abundant towards the bay. These consist principally of limestone or dolomite. That the district from near the Rock to the bay is underlain by Palæozoic sediments is also suggested by the flatness of the country, and it is made practically certain by comparison with the Shamattawa branch and with the Nelson and other neighbouring rivers where similar conditions prevail and where the Palæozoic beds are actually exposed.

Pleistocene.

The rock surfaces are everywhere well glaciated and in most places still preserve the glacial striæ. The direction of striation is usually about southwest. But at the Rock two sets are preserved, the older almost west and the newer about south 18° east. Erratic boulders are numerous. Inland they remain perched on the slopes and tops of the hills, showing that these have not been wave swept as in portions of northern Ontario where most of the erratics have been washed into the hollows.

The glacial drift consists of boulder clay usually of a light somewhat yellowish or greyish colour, with, as a rule, comparatively few boulders.

In some places sands occur. Towards the coast the boulder clay is overlain by stratified clay in which marine shells occur.

Distribution of Rocks.

From Lake Winnipeg to Hairy lake on the Echimamish, the rocks are the grey granite and gneiss cut by red granite dykes and pegmatites. At the inlet of Hairy lake, on the south shore, the rock is the coarse red biotite granite, cutting a coarse

feldspathic rock that appears to be anorthosite. The latter rock consists principally of feldspar (labradorite) in square or rounded crystals, about which are wrapped thin, long augite crystals, giving it the appearance of leopard rock. Other facies of this rock are white, like quartzite, but made up of long feldspar crystals with a square cross-section. The red granite, and probably the anorthosite also, holds inclusions of large size—one hundred feet or greater—of a nacreous mica schist and of the coarse grey gneiss.

On the Echimamish about 8 miles above Hairy lake the rocks supposed to be Keewatin first make their appearance. The first exposure seen was a banded quartzose schist standing on edge. Its general appearance is suggestive of some of the Keewatin iron-formation rocks. A similar rock was seen at the forks of the creek. At the first dam a tuff-like rock, containing feldspar grains, and slaty rocks that might be ash beds, are encountered. At the second dam is a somewhat massive chloritic schist with coarse mica, and quartzose schists. The dip of the rocks appears to be vertical. Veinlets of reddish smoky quartz occur in all these rocks. At the third dam coarse grey gneiss reappears followed by red granite. At the Painted Rock portage the gneiss is well banded; dark bands of augen gneiss alternate with cherty quartz, or pegmatite bands. Biotite and hornblende schist bands also occur. A small dyke of lamprophyre cuts this rock. The chert and hornblende schist resembles iron formation, but the gneiss bands, which are from half an inch to 3 inches wide, form the bulk of the rock. Granite and gneisses continue down the Hayes river past Robinson portage to the half-mile portage by which the canoe route leaves the river. On this portage is a dark hornblende schist somewhat contorted and faulted, and seamed with quartz veinlets and pegmatite and aplite dykes. Across the lake from the east end of the portage is a well jointed phyllite. These rocks continue on the canoe route for about 5 miles, when the Laurentian granite and gneiss come in, and through Pine and Windy lakes and the first 5 miles of Oxford lake only granite and gneiss were seen. At the south point of the west bay of Oxford lake the gneiss is cut by a 20 foot lamprophyre dyke. An island about 2 miles west of Sevenmile point is composed of diorite or diabase somewhat squeezed, and in places epidotized and showing the pillow structure that is common in Keewatin greenstones. The feldspar and coloured constituent are, however, still distinct.

At the first portage above Trout falls is a greyish porphyritic rock with feldspar phenocrysts one-half inch long. At Trout falls is a micaceous schistose rock with small feldspars. It resembles a hornfels, but is almost certainly a squeezed igneous rock. Bands and small lenses of a gabbroidal rock are included in it, and it is veined by somewhat rusty, watery quartz.

At the entrance to Knee lake a disturbance of the compass was noticeable, due no doubt to magnetite on the south side of the inlet which Bell describes as "interstratified with grey siliceous and micaceous schists running about east and west." As we sailed down this part of the lake no opportunity was presented of personally examining these rocks. Through the glass the rocks appeared to be mainly greenstone or massive schist with some quartz veins. At the beginning of the Narrows the rock is a schist with greenish cherty "eyes", varying from one-fourth inch to several feet long. They resemble pebbles somewhat, but are evidently the remnants of

bands of chert, broken by pressure. Inland is a massive greenstone showing pillow structure, with calcite fillling some of the cracks.

Near the end of the Narrows the rock is a green sericite schist with lenticles of calcite and dolomite which on weathering give the rock a pitted surface. It resembles a contact metamorphosed limestone.

In the Narrows a small island which I did not see, called Magnetite island, is reported by Richardson to consist of " mica slate highly impregnated with magnetite, iron ore, and having its thin layers impregnated with layers of that mineral". Bell describes it as consisting of " fine grained magnetic iron in thin layers, interlaminated with others of quartzite and mica schist. The rock is twisted and corrugated and breaks with a splinty fracture".

In the lower expansion of Knee lake the rock is a greenstone, probably diabase, squeezed and in some places epidotized with a well marked pillow structure and cut by quartz veins and dykes of syenite porphyry. On the islands near the lower end of the lake the rock is a mica schist with calcite and dolomite bands cut by some fair sized quartz veins.

These supposed Keewatin rocks continue for a short distance below the lake. Here the grey gneiss reappears and continues to below the Rock, below which only drift is exposed.

This band of Keewatin rocks, it will be noted, extends with a few intermissions, from a short distance up the Echimamish to below Knee lake. Similar rocks are mapped by Tyrrell on Pipestone and Cross lakes on the Nelson, and it seems probable that they belong to the same band.

The rocks seen by the writer had a marked resemblance to the Keewatin and so far as relationships were observed, they were also suggestive of this. The cherty masses seen strongly resembled those of the "iron ore formation" found in the Keewatin of the Lake Superior district. The descriptions given by Richardson and Bell of the occurrence of magnetite are also suggestive of "Iron ore formation".

No minerals of economic importance were observed, but the Keewatin and Huronian belts are worth prospecting. It is in these that the Sudbury, Cobalt, Porcupine, and other camps of northern Ontario occur. The quartz veins seen were "hungry", but it is encouraging to find quartz so common and promising veins might be found by prospecting.

Mr. J. B. Tyrrell reports arsenical pyrites and copper pyrites in the Pipestone Lake area on the Nelson river, and a mica deposit of possible commercial value on Cross lake.

Mr. Wm. Ogilvie of the Department of the Interior has informed me that galena carrying 25 ounces of silver to the ton has been found on a lake north of Nelson House near the divide between Burntwood and Churchill rivers.

Iron deposits of importance may occur in the bands of iron ore formations.

It is perhaps worth noting that among the boulders from the drift along the lower part of the river banded jasper hematite ore, like that of the Lake Superior deposits, occurs, also basalts and melaphyres like the Lake Superior copper rocks, together with beautiful porphyries, and perthite. It is difficult to say where the boulders came from as both westerly flowing and southeasterly flowing glaciers passed over

this section, but these rocks might be almost local and perhaps underlie the Silurian. They are known to occur on the east coast of Hudson bay, also south of James bay, and it seems not improbable that they also fringe the west coast; in other words that the Huronian forms a big basin in which the bay rests, in much the same way as it does about Lake Superior. Wherever we landed in the north country to Port Burwell, iron ore formation rocks were noticeable, so that its distribution would seem to be widespread.

HUDSON BAY.

Hudson bay has a length of about 900 miles and a maximum width of 600 miles. The east coast, which is composed of Pre-Cambrian rocks, is rugged, but the west coast from the mouth of Rupert river at the head of James bay, to the mouth of Churchill is low and flat, being underlain by flat-lying Palæozoic rocks. At ebb tide wide, often boulder strewn, mud flats are exposed. From Churchill north, the Pre-Cambrian rocks obtain and the coast becomes rugged.

York Factory is situated on the narrow point of land which lies between the mouths of Hayes and Nelson rivers. Both have funnel-shaped mouths opening northeastward, the Hayes being about 3 miles across and the Nelson about 15, but rapidly narrowing up stream.

The sediment brought down by the rivers, particularly by the Nelson, has silted up the mouths of the rivers and formed a huge bar, that extends for many miles out to sea. As the Nelson is one of the large rivers of the world it may be expected to maintain a well marked channel through the bar, but the Hayes is rapidly silting up with the material discharged by the Nelson.

Fort Churchill is situated at the mouth of Churchill river on a tidal lagoon enclosed by rock ridges, that form a fine well protected, though somewhat circumscribed, natural harbour. It lies within the barren grounds, but only a short distance beyond the northern limit of the forest. On both sides, a few feet above high tide, are dry sandy flats, parts of an old raised beach. Several other gravel beaches are found on the sides of the hills and up to their summits. These raised beaches are also marked features along Hudson strait and all the way down the Labrador coast. The rocky ridges that enclose the lagoon rise to heights of from 60 to 100 feet, and are composed of a massive coarse-grained feldspathic, arkose quartzite. In the quartzite are a few irregular quartz veins up to a foot in width and a few small pegmatite dykes. From the physiography it is impossible to say whether the bottom of the lagoon has a thick mantle of gravel and thus would be easy to deepen by dredging or whether it has practically a rock botttom; but it is quite possible that it has the former.

On Coats or Mansfield island the sedimentary rocks of the lower Palæozoic could be seen.

Sagluk bay, which is on the south side of Hudson strait between Cape Wolstenholme and Cape Weggs, is a fine harbour about 8 miles long enclosed between hills about 500 to 1,000 feet high. The mouth is about a mile wide. Soundings gave us 10 fathoms of water over the bar at the entrance. The rocks are gneisses and granite with heavy trap dykes. No other rocks than these Laurentian gneisses and granites were seen until we reached the Labrador coast.

No economic minerals were observed at the points touched at on Hudson bay and Hudson strait, and little is known of the mineral possibilities of this section as, except on the east coast of Hudson bay where some prospecting has been done on the iron ore formation, the territory is still unprospected. The observations of explorers, however, would indicate that there are opportunities here for prospecting, and if anything is found there are no natural difficulties that would prevent mining. On the west coast of Hudson bay south of Marble island, Tyrrell has found promising showings of copper ore (chalcopyrite). Iron ore formation occurs along the east coast of Hudson bay and on the west shore of Ungava bay, and as previously remarked, the widespread occurrence of boulders of iron formation makes it probable that it may be found at other localities. Mica is being mined at Lake harbour on the north side of Hudson strait. Graphite occurs in extensive bands to the south of Port Burwell. Gold has been found at the head of Wager inlet, and argentiferous galena, and molybdenite have also been noted.

On account of its great size and its length of coast-line, a tremendously large territory is tributary to Hudson bay. At present it is unprospected, but when the railway is built to the bay, access to all this territory will be comparatively easy and prospecting will no doubt be undertaken. Having regard to the results obtained from prospecting similar formations in northern Ontario, it is only reasonable to suppose that prospecting in the Hudson Bay district will result in some gratifying discoveries.

Timber.

Only the southwestern and southern portions of the district tributary to the bay are likely to furnish timber of economic importance.

Game.

Fishing is likely to become an industry of Hudson bay. Whaling has been prosecuted for years. The possibilities of fisheries so far as known are shown in the following extracts from Geological Survey reports:—

[1] "The numerous large lakes of the several watersheds, and most of the rivers, especially those flowing north and east, are stocked with an inexhaustible supply of food fishes of large size and superior quality, including among other species the lake and brook trout, land-locked and sea-run salmon, whitefish, pike, pickerel, suckers, and ling or freshwater cod. Along the southern, eastern, and northern coasts, the cod is taken in large quantities as far as Ungava bay, which is the present limit where trial has been made for taking this fish. Salmon are found plentifully along the coasts as far as the west side of Ungava bay, which appears to be the western limit of the Atlantic salmon. Very little is known officially or otherwise concerning the fisheries of that great inland sea, Hudson bay, and a great amount of wealth may be lying dormant in its waters from lack of knowledge concerning its fisheries. As regards the inland fisheries, owing to the distance from available routes to a market, they will probably never be used to their full extent, and even the best situated lakes

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[1]Annual Report, Geol. Surv. Can., Vol. VIII. (New Series) 1895, Part L.

will not be fished for many years to come, or until railways are built through the interior. The following kinds (of fish) were taken in the net along the Eastmain river: whitefish, pike, pickerel, and suckers. In the lower parts where the banks and bottom are formed of clay, sturgeon are taken in abundance by the Indians; and from the mouth to the first fall, and in the tributary streams, small whitefish and sea-trout ascend from the sea in large numbers, from about September 1, until the river is closed by ice. Trout are also caught in the rapids of the upper part of the river. The salmon fishery is carried on at a number of places along the river (Koksoak) below the post, during the month of August, and the annual catch averages one hundred tierces for export. Salmon are also taken in the mouths of the Whale and George rivers, the average catch at the former place being fifty tierces, and at the latter one hundred and twenty tierces. Formerly the Company employed a small refrigerator steamer in this trade at Ungava, and the frozen salmon were taken to London for sale. This has been abandoned for several years, and the salmon are now split and salted. The white porpoise is also taken at Ungava on the Leaf river, a stream a short distance north of the mouth of the Koksoak, and at George river. The total amount of oil so obtained is about eighty tierces of forty gallons each.

Accipenser (sp).—A species of sturgeon is very plentiful in the Rupert river, being taken in large quantities at Lake Nemiskau, where the Indians congregate and dry the fish during September. The fish here are usually under three feet in length. Also abundant in the river from Lake Nemiskau to its mouth. Common in the Eastmain river, from its mouth to Conglomerate gorge. Also found in the lower part of the George river, and in the Nottaway at Lake Obatogamau, near its head.

Coregonus clupeiformis (Mitchell. Milner (Common whitefish).—Found abundantly throughout the interior, in lakes and rivers. Largest fish taken in Lake Mistassini, 14 pounds weight. Average weight, 3 or 4 pounds. A small species of whitefish closely resembling the common whitefish is caught in abundance in the shallow water along the east coast of James bay. These fish ascend the rivers of James bay during the autumn months along with sea trout.....

Salmo hearnii, Richardson (Hearne's salmon).—A small salmon with bright red spots on its sides, is found along the northeast coast of Hudson bay, and probably belongs to the species. Its southern limit is a small river a few miles south of Cape Jones. It is taken in nets set in the salt water near Long island, just north of Cape Jones, and also in some small streams flowing into Richmond gulf. The Eskimo also report it common in some of the rivers north of Richmond gulf.

Salvelinus fontinalis (Mitchell), Gill and Jordan (Brook trout).—This fish is abundant in many of the rivers and lakes of the Labrador peninsula. Sea-run fish of this species are plentiful along the shores and lower parts of the rivers from the St. Lawrence to the southern part of James bay..........In the Koksoak and George rivers, the average weight of the sea-run is about seven pounds............

In James bay, the trout taken along the coast and in the lower parts of the rivers are generally small and do not exceed two pounds in average weight...............

In the Koksoak river, for a few miles below Lake Kaniapiskau, large trout were abundant, but lower down they became smaller, until the sea-run fish were met with.

Esox lucius, Linn. (Pike).—Common on the rivers of the southern, eastern, and western watersheds; not so abundant in the Koksoak river. It varies in weight from two to fifteen pounds.

Stizostedium (Mitchell), Jordan and Copeland (Wall-eyed pike, doré, 'perch' of the Hudson's Bay Company.)—Common..........also in the Rupert and Eastmain rivers of the western watershed............not found in the Big river, or streams to the north of it............average weight, three pounds."

"Fish seemed to be everywhere abundant in the lakes and streams...........It is probable that some of the true salmon ascend the inlets and streams west of the northern part of Hudson bay, but the fact was not definitely determined."[1]

"The small streams and lakes (between Hudson bay and Clearwater lake) are well stocked with trout and whitefish. In the Clearwater, large brook and lake trout are plentiful, especially in the rapids below the lakes."[2]

"The fisheries of Hudson bay will probably prove to be its greatest natural resource, as along the east coast the sea is found well stocked everywhere with food fishes. In James bay a net set at random along the shore or about the islands caught fish. These are usually sea-run brook trout and whitefish, identical with the Lake Superior whitefish, and being sea-run are, like the trout, much improved in flavour, These trout and whitefish vary in weight from one to six pounds and are the best of foodfish. Similar fish are found abundantly along the entire coast to Cape Wolstenholme. The Arctic trout or Hearne salmon is found along the northern coast as far south as Seal river, which is situated a few miles north of Cape Jones. This is a beautiful fish with well flavoured, dark pink flesh and it varies in weight from one to fifteen pounds, the average being about five pounds. These fish are salted at Fort Chimo on Ungava bay and fetch nearly the same price in London as salted salmon from the same locality. They are very plentiful about the mouths of the northern rivers and along the coast, while Eskimos report them abundant at the Belcher and other islands lying off the east coast. There is no doubt that the fish equals or surpasses in colour and flavour the salmon of British Columbia. Cod are known to exist in Hudson bay, being taken at Cape Smith and at Comb hill in James bay by members of the expedition. The Eskimos also catch them in Nastapoka sound and at the Belcher islands; at a number of places in James bay they are also taken by Indians.

"The specimens of cod taken by us were not very large, but the men who caught them were Nova Scotia fishermen and said they were true cod and identical with those taken on the Grand Banks. Food for these fish is abundant in Hudson bay and there is no reason why extensive fisheries in this Canadian inland sea should not exist. The undoubted presence of cod in Hudson bay deserves investigation, as a very valuable and exclusively Canadian fishery may be found there. The presence of cod points to that of halibut in the deeper waters of the bay."[3]

"The rivers afford a limited supply of whitefish, and a small species of this fish is caught in the tidewater along the west shore of James bay............Sutton Mill

[1] Annual Report, Geol. Surv. Can., Vol. IX. (New Series) 1896, Pt. F.
[2] Annual Report, Geol. Surv. Can., Vol. IX. (New Series) 1896, Pt. L.
[3] Annual Report, Geol. Surv. Can., Vol. XIII. (New Series) 1900, Pt. D.

lakes are well supplied with a slender variety of grey trout and the streams running to the north into Hudson bay are, at certain seasons, well stocked with brook trout. In August the stream draining Sutton Mill lakes was full of these fish, and several fine specimens were caught on the lake above at the narrows." [1]

"Nothing is at present known of the fisheries of the deeper waters of the strait and bay, and the knowledge of the fisheries of these waters is confined to the coasts and rivers. In the southern part of the bay, large quantities of sea-run trout and whitefish are taken by the natives. The Arctic salmon, a fish superior to the best Pacific salmon, is plentiful along the eastern side of the bay to the northward of James bay, as well as in the mouths of the rivers of the northern and northwest coasts, and along the shores of the strait. Lake trout is a common fish in these northern rivers and lakes. Cod have been taken in several places along the east side of Hudson bay as far north as Cape Smith; on the western side little is known of this fish beyond the occurrence of a few in Roes Welcome, and some small specimens taken among the ice at Fullerton. A cod fishery has been carried on for a number of years at Cape Chidley, and these fish are said to be plentiful along the east side of Ungava bay, but do not appear to go farther westward through the strait from the Atlantic. Cod are reported to be abundant in some of the fiords of the south side of Frobisher bay.

"Two long narrow bays pierce deep into the comparatively flat country of northern Baffin island from the neighbourhood of the bend and a very fine salmon river empties into the more eastern bay................Finding that Arctic salmon were plentiful at the mouth of the little river about a mile from the ships, a small net was borrowed, and two boats were sent away to secure a supply of fresh fish. They returned loaded in an hour, having made but four casts of the net, in which over a thousand splendid fish were taken, varying in weight from three to ten pounds, and aggregating at least 5,000 pounds." [2]

"Speckled trout and whitefish are plentiful at the mouths of all the rivers entering the bay. When at the mouth of the Kaskattamagan, we set the net at low tide and at the following low tide had over a hundred trout and whitefish, over two pounds each." [3]

White porpoise or white whale are plentiful and when Hudson bay is opened up will probably furnish the basis of an industry. When we were at Port Burwell last summer (at the end of August) cod were plentiful and were easily obtained by jigging. From the above it will be seen that the possibilities of fishing industries in this great Canadian inland sea are promising.

Navigation.

At the time we were on the bay and in the straits, navigation was as safe and pleasant as it is anywhere. In fact, for summer navigation the route is ideal. The season is, however, short. The information which could be gleaned regarding the period of navigability confirmed the published opinions of A. P. Low, who estimates it as from the latter half of July to the early part of November—three and a half to four months. Ice in the straits will usually prevent an earlier opening and cold, fog,

[1] Geol. Surv. Can., Vol. XIV, Part F.
[2] The Cruise of the *Neptune*, 1903-4, pp. 296-7; 59.
[3] Geol. Surv. Can., Summary Report, 1905, p. 76.

and snowstorms put an end to it in November. The straits and bay do not freeze solid but are covered with floating ice. The bay itself is navigable for probably about seven months. Churchill harbour is open on an average for five months, and the Nelson for a considerably longer period.

PORTIONS OF ATLIN DISTRICT, B.C.

(*D. D. Cairnes.*)

Introduction.

The field season of 1910 was devoted to mapping and geologically investigating certain portions of Atlin mining district which occupies a position south of and adjoining the western part of the northern boundary of British Columbia. Prof. J. C. Gwillim has reported on Atlin district,[1] and a reconnaissance topographical and geological map accompanies his report; but until and during the years 1899 and 1900, when Prof. Gwillim performed the field work for this map and report, placer was the only form of mining in which any marked interest had been taken. Since then gold, silver, copper, and antimony ores, as well as coal seams, have been discovered, and in some cases prospects have been developed to some extent; and it is now hoped that these deposits will continue to be mined when the gold-bearing gravels, which are slowly becoming exhausted, can no longer be worked at a profit.

The prime object of the past summer's work was to obtain an estimate of the importance of the various ore and coal deposits of the entire Atlin district; and with this purpose in view practically all the properties in the area were examined. In addition, a topographical and geological survey was made of the belt around Taku arm and the upper end of Atlin lake, and was extended from these waters to the south and west as far as time permitted. The area mapped has an average width, from east to west, of 20 miles, extends southerly from the 60th parallel (the British Columbia-Yukon boundary) about 50 miles, and includes the greater number of the more important ore deposits so far discovered in Atlin district. The surveyed area includes also the western edge of the tract covered by Prof. Gwillim's map.

In the performance of our work my party and I received the hearty support of all those interested in mining with whom we came in contact, for which I desire to express my sincere thanks. Particularly am I indebted to Mr. J. A. Fraser, Gold Commissioner, Mr. J. Cartmel, Mining Recorder, and Captain James Alexander, Mr. B. G. Nicol, and Mr. J. Dunham, owners of the Engineer mines, for assistance rendered and for courtesy extended during the season.

My assistants for the summer were Mr. G. G. Gibbins, Mr. P. A. Fetterly, and Mr. John Lanning, who performed the greater part of the topographical portion of the work. Mr. Gibbins also assisted in geology when circumstances permitted.

Summary and Conclusions.

Rich gold-tellurium ores occur in a number of veins on the east side of Taku arm above Golden Gate, at the Engineer mines and adjoining properties; and gold-silver ores have been found in promising amounts at several points on Bighorn creek, on Munroe mountain, Boulder mountain, and elsewhere to the east of Atlin lake, at a number of points on the west side of Taku arm above Golden Gate, and on Hoboe creek, which empties into the upper end of Torres channel, an arm of Atlin lake. A number of wide, persistent veins containing silver-lead ores have been found on the tributaries of Fourth-of-July creek, particularly on Crater creek and in its vicinity. Native copper has been discovered in veins, and also distributed through the basalts on the southern end of Copper island. Antimony ores occur along the

[1] Gwillim, J. C.—"Report on the Atlin Mining district, British Columbia," 1901

west side of Taku arm, about 10 miles above Golden Gate, and large bodies of iron and copper ores have been developed to some extent on Hoboe creek. In addition to these ore-minerals, coal has been found to the northeast of Sloko lake, and probably exists at other points in the neighbourhood, and elsewhere in Atlin district.

A considerable number of these mineral deposits occur along the shores of Taku arm, and have thus direct boat connexion with the railway at Caribou (Carcross). The majority of the other occurrences are on, or within a short distance of navigable waters, and are not far from the railway. During the past summer the railway commission decided that the rates to be charged by the White Pass and Yukon railway on ores should not exceed $1.75 per ton from Caribou to Skagway, whence the ores and concentrates can be sent directly by boat to the various coast smelters, if desired.

It may be said then, that Atlin district possesses quite a variety of economically valuable minerals, which occur, in places, in deposits of considerable size, and in some of the mineral veins pockets of very rich gold ore have been found; also practically all the deposits are readily accessible. The quartz mining industry in this locality has made a good beginning and will probably continue to develop in the future. The results are particularly encouraging when it is considered that, since 1899, when interest was first shown in quartz mining in this district, nearly all persons engaged in mining devoted practically all their attention to placer deposits, and that there has been but a relatively slight amount of prospecting for quartz.

General Character of the District.

TOPOGRAPHY.

The portion of Atlin district surveyed the past summer (1910), as previously mentioned, is a northerly-trending belt, that extends about equal distances on both sides of Taku arm for nearly its entire length, and continues southerly to include the upper portion of Atlin lake. Since the main topographic features of British Columbia here trend northwesterly, and Taku arm runs almost due north, the southern portion of the area mapped adjoins and slightly penetrates the Coast range, while the northern limit reaches well out into the Interior Plateau region which borders the Coast range along its eastern limits. The transition from the plateau to the mountain belt in Atlin district is gradual, so much so that it is, in many places, difficult to determine where one ends and the other commences.

The plateau topography is characterized by two main, striking, features—the numerous, irregularly distributed, wide, deep, steep-walled valleys, and the elevated, and often but slightly undulating inter-valley plateau-fragments that originally constituted portions of an extensive plain. This upland surface here, as elsewhere in the Central Plateau region, bears no relation to rock structure, and the sandstones, shales, granites, schists, limestones, volcanics, etc., have been truncated, regardless of their respective degrees of hardness, structural features, etc. Towards the northern or lower end of Taku arm the plateau surface is approximately 3,200 feet above the lake level, or 5,360 feet above the sea, and towards the southern end it is somewhat higher.

The distinctive plateau characteristics of the upland have been in many places almost if not quite effaced by erosion, and in such cases the topography consists of irregularly distributed, rounded, frequently gently contoured hills whose summits are remarkably uniform in elevation. In other parts, considerable areas of high plain still exist, and enclose within their borders small residuary summits; or, in some cases, detached portions of the upland are merely undulating, and without considerable elevations.

As the Coast range is approached the upland becomes more dissected, and the character of the topography gradually changes to a type composed mainly of rugged peaks and ridges, with intervening valleys bordered by precipitous walls in which numerous

ice masses are nestling. The ice becomes more and more plentiful, until, a few miles to the south of Atlin lake and Taku arm, the great Llewellyn glacier is encountered, which overrides all but the loftier peaks and spurs.

Some time subsequent to the deposition of the Jura-Cretaceous beds—the most recent consolidated sediments in the district—the tract now included in the Central Plateau region of southern Yukon and northern British Columbia, in the writer's opinion, was subjected to a long period of sub-aerial erosion, which continued until a plane-like surface resulted, having an elevation slightly above that of the sea, and with only occasional residuary peaks and ridges rising above the general level; for these results to be attained, the land during this time must have remained in a state of almost perfect stability. This erosion cycle was terminated by a gradual uplift[1] of the Central Plateau region, together with adjoining portions, at least, of the Coast range[2]; and erosive processes thus received new life and energy, with the result that the larger streams commenced deepening their channels in the elevated terrane; the effects of stream action, in this respect, were later accentuated by glaciation. The main ice masses occupied the master depressions, such as that of Taku arm, and were effectual in straightening and planing their walls, and in widening and lowering their floors. The valleys thus produced were wide, deep, and steep-sided. The ice also caused the valleys, in places, to become floored to considerable depths with glacial silts, sands, gravels, boulder clays, etc. The portions of the valley bottoms that were last occupied by these glaciers now contain lakes, since the ice retreated up the valleys so rapidly that only the lower portions were filled with glacial debris, thus causing reversed slopes, and effectually impounding the water above.

In the present plateau region the only representatives of the former glaciers are the few small ice masses that still occupy occasional cirques; so that here nivation[3], or snow-drift action, has been most effective in the uplands, and has tended to smooth over inequalities in the land surface rather than accentuate them. In the Coast Range region, however, on account of the higher altitudes there, the ice is still abundantly present, and the lines of cirques, on opposite sides of the ridges and around the summits, excavate and quarry ever downward and backward until they meet, and rugged knife-like ridges or arrêts, as well as pinnacle-like summits, result.

CLIMATE.

The climatic conditions in Atlin district are fairly well known, and are similar to those in other portions of British Columbia. Placer mining operations on the surface generally commence early in May, and continue until about the first

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[1] Since the most recent consolidated sediments in this portion of the Interior Plateau were deposited before the erosion cycle referred to commenced, it is impossible to determine in this district when the planation occurred. G. M. Dawson, A. H. Brooks, and others, however, have obtained information in other districts, that tends to show that the erosion was largely post-Eocene, and that the uplift which closed the cycle took place in late Pliocene or early Pleistocene times.

Brooks, A. H.—"Geography and Geology of Alaska"; Prof. paper, No. 45, U.S. Geol. Surv., pp. 270-279, 292-296.

[2] Brooks, Hayes, Spencer, Dawson, and others consider the Coast range to be also an uplifted and subsequently dissected plane of mature erosion.

Hayes, C. W.—"An expedition through the Yukon district," Nat. Geol. Mag., vol. 4, p. 128.

In addition, Brooks, Spencer and others consider the Coast range, and the Interior Plateau, to be regions of synchronous planation.

Spencer, A. C.—Bull. Geol. Soc. Amer., Vol. 14, p. 132.

Brooks, A. H.—Prof. paper, No. 45, U.S. Geol. Surv., pp. 270, 286-290, 293.

Mr. R. G. McConnell, on the other hand, although he admits the peneplain characteristics of the Interior Plateau, maintains that the Coast Range topography shows no evidence of ever having been peneplanated.

This entire question will be fully discussed in the writer's detailed report, now in preparation.

[3] Nivation in its different phases, relations, etc., is discussed in the two following articles:

Matthews, F. E.—"Glacial sculpture of the Bighorn Mts.; Wyo.;" U.S. Geol. Surv., 21st Ann. Rep., Pt. II, 1849, pp. 173-190.

Hobbs, W. M.—"Cycle of mountain glaciation;" Geol. Journ., Feb., 1910, pp. 147-163.

of November, and all outside and surface work in connexion with mining and similar industries may be continued for six months in the year. Besides, on account of the very long days in this somewhat northern latitude, surface work may be performed during a considerable part of the summer by night as well as by day, without the aid of artificial light.

The rivers and creeks generally open early in May, but on some of the lakes the ice remains until the first week in June. Slackwater stretches freeze over any time after the middle of October, but occasionally the rivers and lakes remain open until December.

During the summer months the climate is pleasantly warm and neither too dry nor too wet. The winter also, although somewhat long and cold, is enjoyed by those living in the district, and is believed to be very healthful.

FAUNA AND FLORA.

The valleys are generally well forested, but trees of any considerable size are not commonly found more than 500 feet above the valley bottoms; however, in some places the forests extend to 1,500 feet, and quite large trees were found in some sheltered spots, as much as 2,000 feet above this level. The main varieties of trees that occur are white spruce (*Picea alba*), black spruce (*Picea nigra*), balsam fir (*Abies subalpina*), black pine (*Pinus Murrayana*), aspen poplar (*Populus tremuloides*), balsam poplar (*Populus balsamifera*), willows (*Salix*), dwarf birch (*Betula glandulosa*), and a species of alder. Of these, the white, and black spruce are the most abundant and valuable, and occur in about equal numbers; they thrive best in the valley bottoms, where straight and well grown specimens 2 feet to 3 feet in diameter 3 feet from the ground are not uncommon, and the majority of the larger representatives have 12 to 18 inch stumps. The black pine is not nearly so plentiful as the spruce, and only rarely exceeds 12 inches in diameter 3 feet from the ground. The balsam fir thrives best on the slopes near timber-line, where many trees were observed having 12 to 18 inch stumps. On the flats bordering Taku arm, the best of the timber has been cut, in places, for saw-mill purposes. Aspen poplar and balsam poplar constitute a large portion of the forest growth both in the valleys and on the hillsides, but rarely have over 10 inch stumps, and the wood is of value mainly as fuel. Willows, dwarf birch, and alder, occur plentifully both in the valleys and on the slopes, and the dwarf birch, in places, extends to the plateau-level, and with the willows and alder, in places, constitute so dense a growth that walking is very difficult.

Several varieties of wild fruits were noted, of which crow or heather berries (*empetrum nigrum*), are the most plentiful and are found abundantly in most places to above timber line. As these berries are very juicy and palatable, they are much prized by persons engaged in mountain climbing in these northern districts. Low bush cranberries (*Vaccinium Oxycoccus*), high-bush cranberries (*Viburnum pauciflorum*), red currants (*Ribes rubrum*), black currants (*Ribes Hudsonianum*), gooseberries (*Ribes lacustris*), strawberries (*Fragaria cuneifolia*), raspberries (*Rubus strigosus*), blue berries (*Vaccinium uliginosum and V. ceaspitosum*), and Saskatoon berries (*Amelanchier florida*) also occur in more or less abundance in many parts of the district.

Moose, caribou, sheep, and goats are somewhat plentiful in many localities. The caribou is the large giant variety, Osborn's caribou (*Rangifer osborni*); the goat is the white or antelope goat (*Oreamnos montanus*); and the sheep are of two varieties, Dall's mountain sheep (*Ovis dalli*), and the saddle-back or Fannin's mountain sheep (*Ovis fanninii*). Black, brown, and grizzly bears are also plentiful. Wolves, wolverine, beaver, otter, marten, and lynx are somewhat common. Ordinary red foxes, as well as cross, black, and silver foxes, are occasionally found. Ptarmigan

are exceedingly plentiful, of which the rock ptarmigan (*Lagopus rupestris*), and white-tailed ptarmigan (*Lagopus leucurus*), are found above timber line, and during the summer months live mainly on the highest, often snow-capped summits. The willow ptarmigan (*Lagopus lagopus*) exist during the summer months at about timber line. Blue grouse, or Richardson grouse (*Dendragopus Richardsonii*), fool hens, or Franklin grouse (*Canachites franklinii*), willow grouse or Oregon ruffed grouse (*Bonasa umbellus sabini*), are fairly plentiful, and occasionally prairie chicken, or northern sharp-tailed grouse (*Pediaecetes phasianellus*), were also seen; these live mainly in the timber, and preferably in the valley flats. Rabbits, which are periodically plentiful, have been almost extinct for the past three years, but during the past summer they were noticed to be again rapidly increasing in numbers.

The lakes are generally well supplied with fish, mainly lake trout, whitefish, and grayling. Grayling are also plentiful in many of the streams.

General Geology.

GENERAL STATEMENT.

As previously mentioned, the southern portion of the district surveyed the past summer extends into the Coast range, which is mainly composed of granitic rocks, chiefly granodiorites. The geology of the portion of the mapped area to the east and the northeast of the Coast range is somewhat complex and many types of rocks are represented, including sedimentary, metamorphic, volcanic, and plutonic varieties. Highly altered schists, gneisses, and limestones, as well as more recent andesites, sandstones, arkoses, tuffs, and shales have been extensively invaded by granitic rocks. This complex is in turn intersected and partly buried by andesites, andesitic tuffs, and granite—and syenite-porphyries. Newer than all these is a group of rhyolites and rhyolitic tuffs and breccias, which are themselves covered in places by superficial deposits.

TABLE OF FORMATIONS.

Sedimentary Rocks.

System.	Formation.	Lithological Character.
Quaternary	Superficial deposits	Chiefly gravels, sands, boulder clays, silts, muck, peat, and soil.
Jura-Cretaceous	Tantalus conglomerate	Conglomerate chiefly, with some sandstones and shales.
	Laberge series	Conglomerates, sandstones, arkoses, tuffs, shales, slates, and quartzites.
Devono-Carboniferous	Braeburn limestone	Limestones.

Igneous Rocks.

System.	Formation.	Lithological Character.
Tertiary (?)	Wheaton River volcanics	Chiefly rhyolites and rhyolitic tuffs and breccias.
	Klusha intrusives	Chiefly granite-porphyry.
	Chieftain Hill volcanics	Chiefly andesites and andesitic tuffs and breccias.
	Coast Range intrusives	Chiefly granodiorites.
Devonian (?)	Perkins group	Chiefly greenstones, andesites, tuffs, and diabase.

Unclassified Rocks.

Devonian (?)	Taku group	Highly Metamorphosed.	Cherts and slates.
Pre-Devonian, probably all lower Palæozoic.	Mt. Stevens group		Chiefly schistose amphibolites, quartzites, gneisses, and limestones.

DESCRIPTION OF FORMATIONS.

Unclassified Rocks.

Mt. Stevens Group.[1]—The members of the Mt. Stevens group occur mainly in the southwestern portion of the district, in the form of a more or less connected belt, generally 1 to 10 miles wide, that extends along the edge of the Coast Range granitic region. These are predominately schistose amphibolites, gneisses, and limestones. The amphibolites are prevailingly fine-grained, greenish rocks, that vary in structure from highly fissile to slightly schistose. The gneisses are mainly mica varieties having the appearance of mashed, coarsely-textured, granitic rocks. The limestones occur usually in bands 1 to 6 feet thick, associated with the schists.

These rocks are much altered, distorted, and plicated, and are all believed to be of lower Palæozoic age. They are at least the oldest rocks in this district.

Taku Group.[2]—The rocks of the Taku group outcrop only in a few small areas, and consist mainly of cherts and slates. The cherts vary in colour from light grey to black, but grey and black varieties predominate; in places they are reddish on weathered surfaces due to the oxidation of small amounts of contained iron minerals; they are hard and brittle and break invariably into sharp-edged, irregularly-shaped fragments. The slates generally have a slaty structure well developed, cleave readily into thin plates, and are dark, or nearly black.

These rocks are more recent than the members of the Mt. Stevens group, but are apparently older than all the other formations of the district.

Sedimentary Rocks.

Braeburn Limestones.[3]—The Braeburn limestones outcrop extensively in this district, and compose the hills on both sides of Taku arm for 20 miles above Tagish lake. They are at least 3,000 feet thick, and vary in structure from semi-crystalline to crystalline, and range in colour from greyish-blue to almost white. These rocks are prevailingly heavily bedded, and in only rare cases are definite bedding planes distinguishable. The lower members, in places, include some hard cherty or siliceous

[1] This name was first applied in Wheaton River district, Y.T. See:—
Cairnes, D. D.—"Wheaton River district, Yukon Territory"; Geol. Survey Summary Report, 1909, p. 50.
Cairnes, D. D.—"Wheaton River district"; Geol. Survey Branch, Dept. of Mines, Canada. In press.

[2] These Taku rocks correspond with the cherts and slates in Windy Arm district (*a*) and are considered there as probably belonging to Dr. G. M. Dawson's Lower Câche Creek series, (*b*). However, as this correlation with the southern British Columbia rocks is not considered as altogether established, the new name Taku group has been adopted for these rocks in Atlin district and southern Yukon, and is here used for the first time.
(*a*) Cairnes, D. D., "Report on a portion of Conrad and Whitehorse Mining districts, Yukon"; Geol. Survey Branch, Dept. of Mines, Canada, 1908, pp. 26-29.
(*b*) Dawson, G. M.—Report of Progress, Geol. Survey of Canada, 1876-77.
Dawson, G. M.—Ann. Rept., Geol. Surv. of Can., 1887-88, Vol. III, Pt. B, pp. 170, 171.
Dawson, G. M.—Ann. Rept., Geol. Surv. of Can., 1894, Vol. VII, Pt. B, pp. 37, 49.

[3] This name was first employed in the Tantalus coal area. See:—
Cairnes, D. D.—"Preliminary memoir on the Lewes and Nordenskiöld Rivers coal district"; Memoir No. 5, Geol. Survey Branch, Dept. of Mines, Canada, 1910, pp. 28, 29.

beds, which are generally not far above the underlying rocks of the Taku group. These limestones are believed to be mainly of Carboniferous age,[1] but may include Devonian members.

Laberge Series.[2]—The rocks of the Laberge series outcrop over possibly one-half of the entire district mapped this season, and consist of shales, sandstones, quartzites, conglomerates, greywackes, and tuffs, which have an aggregate thickness of at least 5,000 feet. The most conspicuous members of this series are greyish to greenish, finely textured to medium-grained, homogeneous appearing rocks, which frequently exhibit no distinct bedding planes, and are, in places, with difficulty distinguished from some of the andesitic rocks in the district. They are apparently predominantly pyroclastics, and grade into distinct sandstones. Associated with these greenish rocks, in places, are numerous beds of dark grey to almost black, generally soft, friable shales, accompanying which are numerous bands, generally only a few inches in thickness, of brownish sandstones. Near the bottom of the Laberge series are some characteristic, coarse conglomerate beds, the constituent pebbles and boulders of which are mainly granitic rocks, limestone, and greenish volcanics. Boulders 6 to 8 inches in diameter are of common occurrence, and some were noted as much as 2½ feet long. In the vicinity of intrusive rocks the Laberge shales, sandstones, etc., become hard, dense, quartzitic, and cherty.

A number of fossils have been collected from these beds in different parts of southern Yukon, but the specimens were of only a sufficiently definite character to show that the rocks are of upper Jurassic or Cretaceous age. A few invertebrate remains were collected this summer from Atlin district, but these also are poorly preserved, and may belong to either the Jurassic or Cretaceous periods.

The gold-tellurium ores at the Engineer mines and their vicinity, and the antimony vein discovered on the west side of Taku arm, 10 miles above Golden Gate, occur in this series.

Tantalus Conglomerate.[3]—In the area mapped the past season only one small exposure of the Tantalus conglomerate was found, and this was on an inconspicuous summit on the south side of Graham inlet, about 5 miles southwest of Taku Landing; here only about 30 feet of the beds remain, as the overlying portions have been removed by erosion; however, it is probable that more of these conglomerates occur farther to the south and southwest, where the accompanying coal seams should also be found.

The Tantalus conglomerate consists almost entirely of conglomerate beds, the component pebbles of which consist entirely of quartz, chert, and slate. The beds are generally even in texture, homogeneous in appearance, and dark in colour; and

[1] Dr. G. M. Dawson collected Fusilinae from the limestones on Windy Arm, Y.T., near Tagish lake, which are the same as the Braeburn limestones of Atlin district. This shows these to be in part at least of Carboniferous age, and Dr. Dawson considered the Windy Arm members to belong to the Câche Creek series of B. C. (*a*), (*b*). In the writer's report on Windy Arm district, these limestones are considered as probably belonging to the Upper Câche Creek series (*c*), but as this correlation is not considered to be altogether established, the name Braeburn limestones is used in this report, as these limestones have been traced from Tantalus district, where the name was first used, to Taku arm.

(*a*) Dawson, G. M.—Report of Progress, Geol. Survey of Canada, 1887.

(*b*) Dawson, G. M.—"Report of Explorations in British Columbia"; Report of Progress, 1876-77, Pt. B., Vol. VII.

(*c*) Cairnes, D. D.—"A portion of the Conrad and Whitehorse mining district"; Geol. Survey Branch, Dept. of Mines, Canada, 1908, pp. 25-26.

[2] This name was first employed in the Braeburn-Kynocks area, see:—

Cairnes, D. D.—"Preliminary memoir on the Lewes and Nordenskiöld Rivers coal district"; Memoir No. 5, Geol. Survey Branch, Dept. of Mines, Canada, 1910.

The Laberge rocks also occur in Wheaton River district, see reports mentioned above, under "Mt. Stevens Group."

[3] This name was first applied in Tantalus coal area. The Tantalus conglomerates have also been found in Braeburn-Kynocks coal area, in Wheaton River district, and also in Whitehorse district. See reports mentioned in the above footnotes.

their component pebbles are rarely over 2 or 3 inches in diameter. Associated with, and intercalated in these conglomerates are a few shale beds, and in most places also, where any considerable portion of the conglomerate section has been seen, coal seams have been found.

The conglomerate beds overlie, apparently conformably, the members of the Laberge series.

Superficial Deposits.—Overlying all the consolidated rock formations of the district are the Quaternary superficial deposits, which consist of both Pleistocene and recent accumulations. The glacial deposits consist chiefly of gravels, sands, silts, and boulder clays, which floor all the master valleys of the district, and in fact the presence of the numerous lakes is due to their valleys being dammed by glacial accumulations. The channels of the larger streams are also mainly in these deposits, which, in many places, reach well up on the hillsides. Overlying these Pleistocene materials are the recent accumulations, composed mainly of fluvial and littoral sands, gravels, and silts of the present waterways, muck and soil.

Igneous Rocks.

Perkins Group.[1]—This group consists mainly of greenstones, andesitic rocks, and basic eruptives, apparently diabase. The largest exposure occurs on the south side of Graham inlet, almost due south of Taku mountains, is about 1½ miles wide by 2 miles long, and consists mainly of greenstones and rocks resembling andesites and andesitic tuffs. The only other outcrops noted occur on the east side of Taku arm below Golden Gate, are only a few hundred feet in diameter, and consist of diabase-like rocks. The greenstones are mainly pale-greenish to greyish-green in colour, and are generally finely textured, but still distinctly recognizable in the field as holocrystalline. The andesitic rocks are also greenish in colour, and have always a macroscopically aphanitic ground-mass which frequently encloses distinct plagioclase and hornblende phenocrysts. The rocks which appear to be diabases are prevailingly coarsely textured, dark green, and appear to consist almost entirely of basic plagioclase, pyroxene, and chlorite.

These Perkins members are more recent than the Mt. Stevens group, and older than the Coast Range intrusives, but evidence was not obtained to show whether the Taku or the Perkins group is the newer.

Coast Range Intrusives.—The Coast range is built up largely of the granitic rocks of the great Coast Range batholith which is exposed along the upper ends of Atlin lake and Taku arm, and trends thence northwesterly. Many dykes and irregularly shaped intrusive areas of these granitic rocks, which have been called the Coast Range intrusives,[1] outcrop in the vicinity of Taku arm. These intrusives are prevailingly fresh and unaltered in appearance, and are predominantly greyish in colour, although sufficient orthoclase exists in places to give them a somewhat pinkish or reddish aspect. Under the microscope these rocks prove to be generally granodiorites, or quartz granodiorites, but true granites and diorites also occur. In places, these intrusives are quite porphyritic, and feldspar phenocrysts 1½ to 2 inches long are occasionally to be seen.

The Coast Range batholith is believed by the various geologists who have studied it to have come into existence as such, in about Jurassic times. However, in Atlin district, pebbles and boulders of these granitic rocks occur in the lowest conglomerate beds of the Jura-Cretaceous sedimentary series, showing the granitic materials to be the older; and also dykes and intrusive masses of rocks having identically the same appearance, cut the upper members of the Laberge series, which is at

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[1] The name Perkins group was first applied in Wheaton River district, Y.T. See reports referred to in the previous footnotes.

[1] The name Coast Range intrusives was first employed in Wheaton River district. See reports mentioned in previous footnotes.

least, as mentioned above, over 5,000 feet in thickness, and thus indicate that these granitic rocks are more recent than the sedimentaries. The Coast Range intrusives are thus of two ages, and chemical and microscopical tests are now being made to determine if any practical method can be found for distinguishing these rocks in the field where contacts with formations of known ages are not obtainable. So far it has not been possible to separate the older of these granitic rocks from the newer.

A number of the mineral-bearing quartz veins of the district occur in these intrusives.

Chieftain Hill Volcanics.[1]—These rocks occur mainly in two belts, one of which extends from Taku Landing northwesterly towards the mouth of Tutshi river, and is 2 to 6 miles wide, and possibly 25 miles long; the other area lies to the west of the Engineer mine and Edgar lake, and is 4 to 6 miles wide and apparently about 10 miles long. Other small exposures and numerous dykes were noted in various localities.

The Chieftain Hill volcanics are mainly mica-hornblende, and augite-andesites, and andesitic tuffs and breccias. They vary considerably in mineralogical composition, and have a wide range of colour, showing many shades of red, blue, green, and brown, but they generally possess a rather typical andesitic habit. A distinct porphyritic structure is prevailingly noticeable, and phenocrysts of feldspar are generally present, while those of hornblende and biotite frequently occur. Some augite-andesities are dark-greenish, dense, finely textured, rocks in which none of the mineral constituents are discernible, and in which no phenocrysts are apparent to the unaided eye. Rocks with a dense, aphanitic, reddish, greyish, or greenish, ground-mass, in which well formed plagioclases are abundant, are, however, the commonest types.

These volcanics are more recent than the Coast Range intrusives, and for the greater part newer than the sediments of the Laberge series, but also appear to be in part contemporaneous with these beds.

Klusha Intrusives.[2]—Klusha intrusives occur chiefly as dykes which are to be found in most portions of the district; they are, mainly at least, granite-porphyries, and are prevailingly greyish in colour, and of a coarsely granular habit, so that all the principal mineral components are distinctly discernible with the unaided eye. These rocks possess a holocrystalline porphyritic structure, and consist of a micro-granitic, or micropegmatitic quartz-feldspar ground-mass, in which alkali feldspar and lime-alkali feldspar phenocrysts are plentiful, and in which biotite and hornblende commonly occur.

These intrusives are more recent than all the Jura-Cretaceous sediments, and also the Chieftain Hill volcanics, and are thus probably of Tertiary age.

Wheaton River Volcanics.[3]—No extensive areas of Wheaton River volcanics occur in this district, but numerous dykes and small patches, generally only a few hundred feet or less in diameter, were noted. These volcanics include rhyolites and rhyolitic tuffs and breccias, which are prevailingly nearly white to light grey in colour. In places, however, these rocks contain considerable pyrite, which oxidizes to limonite and gives them a bright red, to brownish-red or yellowish-red appearance. The rhyolites have always a megascopically aphanitic ground-mass, in which phenocrysts of quartz, orthoclase, and plagioclase occur. The quartz exists frequently in

[1] The name Chieftain Hill volcanics was first applied in Wheaton River district. See reports mentioned in previous footnotes.

[2] The name Klusha intrusives was first given in Tantalus coal area, Y.T. These rocks have also been identified in Conrad and Whitehorse mining districts and in Wheaton River district, Y.T. See reports mentioned in previous footnotes.

[3] This name was first applied in Wheaton River district in 1909. See reports referred to in previous footnotes.

distinct dihexahedrons, which are as much as $\frac{1}{32}$ of an inch in diameter. Well formed megaphenocrysts of orthoclase and plagioclase also occur, but those of the alkali feldspar are much the more plentiful. The tuffs and breccias consist chiefly of fragments of rhyolitic materials, that vary in size from microscopic to several inches in diameter.

These Wheaton River volcanics appear to be nearly contemporaneous with the Klusha intrusives.

ECONOMIC GEOLOGY.

GENERAL STATEMENT.

Atlin became known as a productive placer gold camp early in the year 1898, after the discoveries by Miller and McLaren,[1] who first found gold in paying quantities, in this district, on Pine creek, in January of that year. Since that time a number of creeks on the east side of Atlin lake, and within distances of 15 or 20 miles from the town of Atlin, have continued to make this district one of the most important placer camps in Canada. During the summer of 1899 a number of quartz claims were located, and since that time a few properties of this type have been developed more or less from time to time, but the attention of those interested in mining has always been mainly directed to placer deposits.

In the portion of Atlin district mapped during the past season, no placer deposits have been discovered, but a considerable number of quartz claims have been located, practically all of which were examined during the course of the regular field work. In addition, during the latter part of the season, the more promising deposits of ore and coal, discovered in the remaining portions of Atlin district, were also visited. The placer deposits were not examined, as the geology of these deposits was covered by Prof. Gwillim's previous work, and conditions pertaining to them have not materially altered since. Development has been more rapid in the case of the other mineral deposits in the district, so that their examination was considered the more urgent. The chapter on economic geology in this report, therefore, describes the deposits of economically valuable minerals, other than placer gold, that have been discovered not only in the area surveyed during the past season (1910) but also in the greater portion of the entire Atlin mining district (Fig. 1).

During the past summer some pockets of remarkably rich gold-tellurium ore were found at the Engineer mines on Taku arm and in this vicinity, and this discovery has helped to arouse enthusiasm in quartz mining in the district, so that the future of this industry is now much more promising than it was.

For convenience of description the economically important mineral deposits other than of placer gold, in the district, may be tentatively classified as follows:—

(*a*) Gold-tellurium quartz veins.
(*b*) Gold-silver quartz veins.
(*c*) Cupriferous silver-gold veins.
(*d*) Silver-lead veins.
(*e*) Copper veins.
(*f*) Antimony veins.
(*g*) Contact-metamorphic deposits.
(*h*) Coal.

GOLD-TELLURIUM QUARTZ VEINS.

General.

Gold-tellurium quartz veins have been discovered in Atlin district in only one locality which is situated on the east side of Taku arm above Golden Gate. The

[1] For a historical account and description of placer mining in Atlin district, see:—Gwillim, J. C.—"Report on the Atlin Mining district, British Columbia"; Geol. Surv. of Can., 1901.

MINERAL LOCATIONS

1 Antimony Claim
2 Beavis Mine
3 Big Canyon Group
4 Calahan Group
5 Copper Veins
6 Dundee Group
7 Engineer Mines
8 Gleaner Group
9 Imperial Mines
10 Kirtland Group
11 Lakefront Claim
[illegible]
[illegible]
14 Lawson Group
[illegible]
16 Petty Group
17 Rupert Group
[illegible]
[illegible]
20 White Star Group

greater number of these veins, and the bulk of the rich ore found in them, occur at the Engineer mines, but veins carrying pockets of good ore have also been discovered on adjoining properties.

The Engineer Mines.[1]

General.—This property is situated on the east side of Taku arm, about 10 miles above Golden Gate (Fig. 1) and consists of eight connected claims, four of which extend to the waters edge and the other four adjoin these to the east. This group is owned by the Northern Partnership, composed of Captain James Alexander, Jno. Dunham, B. G. Nicol, and K. Wawrecka.

The Engineer mines were first located in 1899, and a joint stock company was formed, known as the Engineer Mining Co., which held the property until 1906. The claims are then believed to have lapsed, and were located by Edwin Brown and partners, who held the property one year, when it was acquired by the present owners.

Summary.—The ores at the Engineer mines occur in veins, in Jura-Cretaceous shales, slates, and other dark, finely textured sediments. The veins range from simple veins a few inches in thickness to compound veins over 200 feet thick, and consist largely of quartz, calcite, and intercalated and brecciated wall-rock. The chief metallic mineral in these veins is native gold, and, in addition, there are small particles of tellurides, some native antimony, and occasional particles of pyrite. The veins are thus of value only for their gold content.

It is not even approximately known what average amounts of gold the larger veins contain, but tests so far have given results ranging from traces to about $10 per ton. Pockets and shoots of remarkably rich ore occur in a number of the narrower veins, that have thicknesses of from 6 inches to 4 feet, and it is these that have been mainly prospected and developed.

This group of claims is easily accessible, being situated on the shore of Taku arm, and thus directly connected by navigable water with Caribou on the White Pass and Yukon railway. The property is still in the uncertain prospect stage, but possesses some promising features.

Geological Formations.—The geological formations at and in the vicinity of the Engineer mines are predominantly Jura-Cretaceous shales, slates, and finely textured greywackes and tuffs of the Laberge series, which have been invaded to a considerable extent by dykes of andesite and granite-porphyry. The ores occur prevailingly in dark to almost black shales and slates, which are in places faulted, folded, and considerably distorted, but which have a general strike of about N 63° W, and dip at an average angle of about 35° to the northeast, *i.e.* away from the water's edge.

General Characteristics of the Veins.—Two large central compound veins or hubs, consisting of quartz and intercalated and brecciated shale, slate, and altered rocks, occur, from which several veins radiate in prevailingly northwesterly and southeasterly directions. In addition, a number of veins have been discovered, which are not, as yet, traceable into any central quartz area.

Hub A (Fig. 2) is at least 200 feet wide at its widest point, and is over 300 feet in length, but, owing to a covering of superficial deposits, neither the entire length nor width of the vein was obtained. This mass consists mainly of quartz, but also contains a large proportion of intercalated bands of shale and slate. In places, bands of shale 1 to 2 inches thick alternate with veins of quartz of similar thickness. At

[1] Gwillim, J. C.—"Report on the Atlin mining district, British Columbia"; Ann. Rep. Geol. Surv. of Can., 1899, Vol. XII, p. 45 B.
"Atlin district"; Ann. Rep. Geol. Surv. of Can., 1900, Vol. XIII, p. 55A.
Report of the Minister of Mines of British Columbia, 1900, pp. 760, 761, 778; 1904, pp. 80-81.
British Columbia Bureau of Mines, Bulletin No. I, 1910, pp. 5-6; Herbert Carmichael, Provincial Assayer.

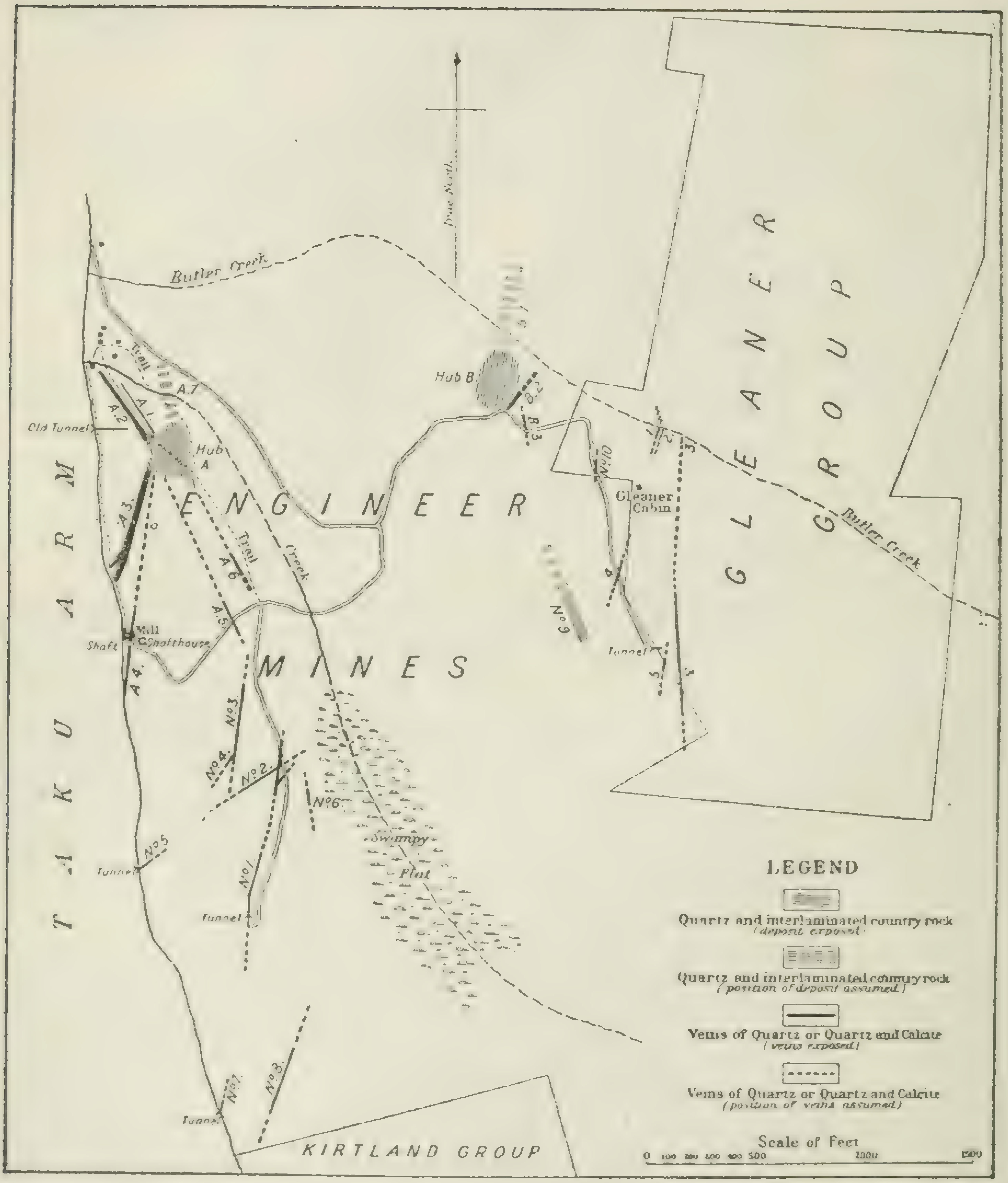

Fig. 2.—Vein Outcrops at Engineer Mines and Gleaner Group, Atlin Mining District, B.C.

other points, owing to breaking and crushing, the rock has been much brecciated, and the particles have been cemented together mainly with quartz and calcite. The relative amounts of those secondary minerals and original rocks vary greatly, so that in some places there is a considerable predominance of rock, and in others the vein consists almost entirely of quartz and calcite.

Three veins A 1, A 2, and A 3, have been definitely traced to a junction with hub A. In addition, A 4, A 5, and A 6 strike towards A, and although, owing to superficial covering, they could not be followed absolutely to the central area, their strikes indicate that they join it. The strike and form of the quartz also indicate the presence of a wide vein as indicated by A 7, but this is not exposed.

Hub B is very similar in appearance to hub A, contains a large amount of intercalated and brecciated shale and slate, and is in reality a compound vein. It is at least 270 feet wide, as this much is exposed to view, but neither wall was found. Towards the edges of the vein, the proportion of rock gradually increases, and probably this increase continues, producing walls of an indefinite character.

The following tables give the main characteristics of all the veins, except the two hubs which have just been described:—

Vein.	Strike.	Dip.	Thickness.	Distance Traced.	Remarks.
A 1....	N 68° W	80° to NE	6 to 10 feet..	300 + feet..	Consists mainly of quartz.
A 2....	N 70° W	Apparently nearly vertical.	20 to 30 feet.	400 + feet...	Consists mainly of quartz.
A 3....	N 18° W	Nearly vertical.	Average 30 feet.	350 + feet...	Towards southern end and near the shore, the vein splits up into several veins 6 inches to 2 feet in thickness. Vein includes considerable intercalated shale, in places up to 20 per cent of its volume; the remainder of the vein is mainly quartz.
A 4....	N 30° W	70° to 80° to SE	2 to 3 feet...	250 feet.....	Consists mainly of quartz.
A 5....	N 64° W	80° to NE	2 to 10 inches	300 feet.....	Consists mainly of quartz.
A 6....	N 64° W	70° to 80° to NE	4 to 20 feet..	200 + feet.	Where thin, vein consists mainly of quartz, but in thickest portions, includes up to 30 per cent of intercalated shale layers. Vein to a considerable extent lies conformable to bedding planes of formation, and so differs from the majority of the veins.
B 1....	N 20° W (?)	(?)	50 + feet...	30 feet......	Contains up to 30 per cent or 40 per cent of brecciated and interlayered rock.
B 2....	N 5° E	Vertical (?)..	10 to 12 feet.	50 feet......	Consists mainly of quartz.
B 3....	N 64° W	(?)	3 to 4 feet...	100 feet....	Consists mainly of quartz.
No. 1...	N 21° W	50° to 60° to NE	6 inches to 3 feet.	600 feet.....	Consists mainly of quartz.
No. 2...	N 23° E	Nearly vertical in most places.	2 to 12 inches	200 + feet. .	Consists mainly of quartz.
No. 3...	N 28° W	Approx. 70° to NE	1 to 10 inches. In most places 4 to 6 inches.	450 + feet...	Consists mainly of quartz. Intersects No. 4 vein and persists through it.
No. 4...	N 1° E	80° to SE	2 to 6 inches	50 feet......	Consists mainly of quartz.

Vein.	Strike.	Dip.	Thickness.	Distance Traced.	Remarks.
No. 5...	N 24° E	Nearly vertical.	6 to 14 inches	30 feet......	Consists mainly of quartz. Thought by owners to be, and probably is, the southwest extension of vein No. 2, but between the most southwestern known portion of No. 2 and the nearest exposed part of No. 5 is a distance of over 400 feet, so the correlation is uncertain ; however the dips, strikes, and characters of the outcrops are similar.
No. 6...	N 24° W	70° to SE	6 to 18 inches	50 feet......	Consists mainly of quartz.
No. 7...	N 20° W Approximately	Nearly vertical.	4 to 16 inches	30 feet......	Consists mainly of calcite and quartz, the calcite predominating.
No. 8...	N 13° W	80° to SW	10 to 15 feet.	300 feet.....	Brecciated vein, composed almost entirely of broken and comminuted portions of shale and slate cemented together, chiefly by quartz and also to some extent by calcite. The proportion of the gangue minerals in the vein varies from possibly 75 per cent or 80 per cent to less than 50 per cent.
No. 9...	Apparently N 56° W	(?)	50 + feet...	150 feet.....	Strike indicates that it joins hub B, which it much resembles in character, being a typical brecciated vein.
No. 10..	N 47° W	(?)	Approximately 4 feet.	75 feet.....	Consists mainly of quartz, and varying amounts of intercalated shale and altered rock.

All bearings in this report, unless otherwise mentioned, are magnetic. The magnetic declination in this district is about 33°.

Mineralization of the Veins.—The gangue and ore minerals of these veins are mainly quartz, calcite, native gold, one or more telluride minerals, pyrite, limonite, and native antimony. The majority of the narrower veins are composed almost entirely of quartz, with relatively small amounts of calcite; however, as mentioned above, the fissure filling of No. 7 vein consists predominately of calcite. In addition to these two gangue minerals a number of the veins, particularly the hubs and wider veins, contain considerable intercalated and brecciated shale and related materials, and also a greenish chloritic mineral which appears to result from the alteration of the wall-rocks.

The quartz is commonly well crystallized, and long delicate prisms are very characteristic; these occur in parallel bands with the familiar comb structures, or radiate from some central particle or mass of rock or ore. In the considerable amount of intercrystal space that thus results, the metallic minerals have largely been deposited. Dense, massive, quartz occurs in places, mainly in the larger veins, but even there, vugs lined with quartz crystals are of frequent occurrence. Calcite occasionally exists in distinct crystals which usually line the interior of the various small cavities in the veins.

Native gold is the most common metallic mineral in the veins, and is in places plentifully distributed through pockets or shoots of ore, either in fine grains or thin scales of varying dimensions, which gradually merge into leaves half an inch across. Associated with the gold are occasional minute and imperfect prismatic forms of a brass-yellow telluride, the principal base of which is gold; this telluride is probably mainly calaverite. A few specimens of native antimony were also found. Occasional particles of pyrite, and its oxidation product, limonite, also occur in some of the veins.

Development Work.—The original Engineer Mining Company ran a cross-cut tunnel about 200 feet long from the water's edge to tap hub A, but instead of cut-

ting this quartz body, the tunnel encountered only vein A 2, and did not extend to the larger deposit; about 100 feet of drifts and cross-cuts were driven from this tunnel. The Company also sank a shaft about 20 feet deep on vein A 4, near the point where it comes to the shore of Taku arm. They also sank a compartment shaft that was intended to tap vein A 4 just back of the present mill; this shaft was filled with water when visited by the writer, but is said to be about 70 feet deep. A few small surface cuttings were also made by this Company.

The Northern Partnership deepened the 20 foot shaft on vein A 4, but had to cease operations until winter on account of water. Two tunnels were also commenced on veins No. 5 and No. 7, from the water's edge, but were each only driven about 10 feet; a tunnel was also started on vein No. 1 (see fig. 2), but was only run about 30 feet. Vein No. 1 has been followed almost continuously for 600 feet by trenching from 6 inches to 6 feet deep. A trench 1 to 7 feet deep has also been dug along the outcrop of vein No. 2 for about 200 feet. In addition, a few shallow trenches and open-cuts have been made in hub A and hub B, and on veins A 5, A 6, B 3, No. 3, No. 4, No. 6, and No. 8. This constitutes practically all the development work that has been so far performed on the Engineer Mines property. During the past season the Northern Partnership performed their work practically all on the surface, with the object of determining as far as possible the number of veins, and the portions of them, that contain ore immediately available for milling. This surface prospecting and development was carefully, although necessarily slowly conducted, and has given very satisfactory results.

A 2 stamp Joshua Hendry mill, the construction of which was commenced several years ago, was completed during the early part of the season, and was in operation during the latter part of the summer.

Values.—But few assays have been made by the Northern Partnership of the ores on their property; instead, the owners have depended almost entirely for guidance in development upon the visible presence or absence of native gold, with the result that no reliable estimate can be formed as to the probable amount of gold that the hubs and larger veins contain. Minute specks of native gold are, however, to be seen in all the larger deposits, and the few assays that have been made of the quartz from these gave results ranging, in most cases, from traces to about $10 per ton. Very rich ore occurs in pockets or shoots in a number of narrower veins, the best being obtained from veins No. 1, No. 2, No. 5, No. 7, and A 4; in addition, a number of sacks of good ore were taken from No. 3, No. 6, A 5, and A 6.

The pockets appear to occur prevailingly at points where the veins are intersected by cross-fissures; they vary considerably in size, some holding only a portion of a sack, while others contain several sacks, and the greater part of the ore has a value of from $1 to $5 per pound. The only body of good ore of sufficient size to be termed a shoot, that has so far been explored, is in vein No. 1; this has an average thickness of from 1 to 2 feet, is at least 20 to 30 feet in length, measured along the strike of the vein, and has been followed downwards for 30 feet without any apparent depreciation in value. This shoot might possibly better be described as a portion of a vein in which pockets are more numerous than is usually the case, but practically all the material so far obtained from it has been pay ore.

The first 800 pounds of selected ore that was milled during the past season yielded 20 pounds 4 ounces (Troy) of gold, and the next 1,000 pounds gave 20 pounds 8 ounces (Avoirdupois); and, in addition, the tailings in each case are claimed to contain approximately 30 per cent to 40 per cent of the original gold content, but this was not investigated. The ore taken from the various prospecting trenches, open-cuts, short tunnels, etc., during the season up to September 1, was valued at about $25,000, and from the part of this that was milled, $8,000 in gold bullion was obtained.

In addition to the high grade pockets and shoots, considerable of the quartz between these on veins No. 1, No. 2, No. 5, and A 4, will probably pay to mill, and in some places it is claimed to run from $100 to $200 per ton, but the writer does not believe it will average more than a small portion of the smaller of these amounts. The entire 3 feet of ore in the shaft on vein A 4 is reported by the owners to average $200 per ton. Some splendid ore specimens have been obtained from No. 7, but this vein has not been explored for over 10 feet, and not more than about a sack of the rich material has been obtained.

The Gleaner Group.

General.—The Gleaner group consists of three claims and a fraction that lie to the east of and adjoin the Engineer mines (Fig. 1). These claims were located in 1900, and in 1901 the owners formed a joint stock company, known as the Gleaner Mining and Milling Company, who still hold the property. This Company is capitalized for $250,000, the president is Mr. David Stevens, the secretary-treasurer is Mr. P. F. Scharschmidt, of Whitehorse, Y.T., and the board of directors include the above named officers and Mr. R. Butler, of Atlin, B.C., Dr. Lindsay, of Calgary, Mr. D Von Cramer, of Vancouver, Mr. M. H. McCabe, of Victoria, and others.

A wagon road 4,300 feet long, with a good grade, was constructed during the past summer from the tunnel on the Gleaner group (see Fig. 2) across the Engineer property, to the shore of Taku arm, from which point there is direct steamboat connexion with Caribou on the White Pass and Yukon railway, 65 miles distant.

Geological Formations.—The rock formations on the Gleaner claims are the same as at the Engineer mines, *i.e.*, they consist mainly of the Jura-Cretaceous shales, slates, greywackes, tuffs, and breccias of the Laberge series, which have been invaded by occasional dykes of andesite and granite-porphyry. The sediments are in places somewhat folded, faulted, and distorted, but in a general way have a fairly uniform strike of about N 60° W, and dip at 30° to 40° to the northeast, under the high mountains in that direction.

The Veins.—The ores on these claims all occur in quartz veins, mainly in the dark, finely textured members of the Laberge series, and at least four veins have been discovered on the property (see Fig. 2). No. 1 and No. 2 veins are simple fissure-fillings, and consist mainly of quartz. These are exposed on the south bank of Butler creek, strike about N 20° W, and are from 20 to 30 feet apart. On the north side of Butler creek a vein from 3 to 10 inches thick is also exposed, which is, in all probability, the extension of either No. 1 or No. 2. This is here broken and offset by a number of faults, having displacements of from a few inches to several feet each. On the wagon road, about 750 feet from where these veins cross Butler creek, a vein is exposed (marked No. 4, see Fig. 2) which is traceable about 100 feet, strikes N 20° W, is from 1 to 2 feet thick, and is probably also the extension of either No. 1 or No. 2 vein. On the south side of Butler creek, about 80 or 100 feet above No. 2 vein, No. 3 vein is exposed, and has a thickness of 3 to 4 feet; this is really only a faulted zone in the formation, into which has been introduced a considerable amount of quartz, which occurs mainly in the form of narrow stringers, and also as a cement uniting the various rock fragments. About 700 feet from here, in a southerly direction in the apparent line of strike of No. 3, is a similar zone or compound vein about 10 feet thick, that is apparently the extension of No. 3, and has been traced for at least 400 feet, with a general strike about N 25° W. No. 5 vein is exposed about 100 feet to the south of the Gleaner tunnel, is apparently about 2 feet in thickness, and strikes approximately N 15° W.

Quartz is practically the only gangue mineral in these veins, and with the intercalated layers and fragments of wall rock, constitutes nearly the entire vein-filling,

[1] Report of Minister of Mines, British Columbia, 1904, p. G. 81, and G. 91.

with the exception of the small amounts of native gold, iron pyrite, and iron oxide. Where the gold occurs it is generally finely disseminated through the quartz, but in places thin leaves and flakes half an inch across have been found. This mineral has so far been obtained chiefly in pockets or shoots which are generally small, but during the latter part of the past summer a pocket or shoot was discovered on the north side of Butler creek that contained several sacks of ore, through all of which native gold was plentifully visible to the naked eye.

Development.—Some small open-cuts and trenches have been made on the veins outcropping along Butler creek, and a tunnel 180 feet long has also been driven from a point about 1,000 feet to the south of the creek, that was intended to cross-cut vein No. 3, but so far this quartz deposit has not been encountered.

The Kirtland Group.

The Kirtland group is owned by Thos. Kirtland and Captain W. Hawthorn, R.N., and consists of six claims that extend along the east shore of Taku arm from the Engineer group southward to 100 feet or so across Hale creek, a distance of approximately 8,000 feet (Fig. 1). The geological formation on this property is the same as at the Engineer mines, and on the Gleaner group, and the veins that have so far been discovered resemble those found on these properties. However, on the Kirtland group, only a slight amount of prospecting has yet been performed, and this has practically all been confined to the Jersey Lily claim, which adjoins the Engineer group. Several simple quartz veins a few inches in thickness, and one brecciated vein 2 to 3 feet thick, have been discovered. Two pits about 10 and 14 feet deep respectively have been sunk, and a few open-cuts and trenches have been dug.

Since this property adjoins the Engineer mines, and the formation is apparently identical on the two properties, it is hoped that rich ores will also be discovered on the Kirtland group when the claims have become more thoroughly prospected. So far little gold has been found.

GOLD-SILVER QUARTZ VEINS.

General.

Gold-silver quartz veins have been discovered at a number of points in Atlin district, the most important of which are: on the White Moose group and on the Rupert group on the west side of Taku arm above Golden Gate; on the Lawsan group on Bighorn creek; at the Beavis mine near the town of Atlin; on Munroe and Boulder mountains, east of the town of Atlin; and on the Brothon and Alvine claims on Hoboe creek near the head of Atlin lake.

The White Moose Group.

General.—The White Moose group is situated on the west side of Taku arm opposite the Engineer mines (Fig. 1), and consists of eight claims, which are owned by four persons, three of whom are Dr. H. E. Young, and Messrs. J. Johnson and Robt. Grant. Two veins, distinguished as the North and South veins, respectively, have been discovered on this property. Five claims have been located in the valley bottom along the strike of the North vein, and these extend along the shore from a point about half-a-mile above the mouth of Buchan creek southward, the length of the five claims. The other three claims have been located along the South vein, which strikes in a northwesterly direction; and the most easterly of these claims extends to the shore of Taku arm, and adjoins the most northerly of those located on the North vein.

Geological Formations.—The rocks in the vicinity of the White Moose group, with the exception of occasional dykes, all belong to the Mt. Stevens group of lower

[1] Report of Minister of Mines, British Columbia, pp. G. 81, G. 82, G. 92.

Palæozoic (?) age and consist mainly of greenish schistose amphibolites that are much contorted, faulted, and metamorphosed.

The Veins.—Outcrops which are thought to be portions of one vein—the North vein—occur at intervals for a distance of over 5,000 feet, strike in a general way N 40° W, and dip to the northeast at angles ranging from 40° to 60°. It is possible, however, that these various exposures represent more than one vein, but they all lie in the same general line of strike, dip to the northeast, contain identical mineral combinations, and in every way appear to have a common origin and to be parts of one fissure-filling; so all these vein-portions are here, for convenience in description, considered as belonging to the so-called North vein, which varies in thickness from 18 inches to 4 feet, and consists mainly of quartz, which is predominately massive, bright, and white to colourless. In places, slightly vesicular white quartz occurs, and occasional small patches of white calcite were also noted. In addition to these gangue minerals, the vein is fairly well mineralized, chiefly with argentiferous tetrahedrite (grey copper), pyrite, and chalcopyrite (copper pyrites), but galena and malachite (green copper stain) also occur. At the most northerly exposure of the vein, where it outcrops at the shore, a small shaft has been sunk; here the vein is about 2 feet thick and in places is composed largely of metalliferous minerals, mainly tetrahedrite, chalcopyrite, and galena, with subordinate pyrite, and malachite. Towards the southern end of the claims on this vein, some trenches and open-cuts have been made, a shallow prospect shaft has been sunk, and a cross-cut tunnel has been commenced, which has, however, not tapped the ore as yet. The vein at the shaft, and in the vicinity, has an average thickness of about 2 feet, and above the tunnel is 7 feet thick, but is here not so well mineralized as in places where the thickness is less. It is not known at all definitely how much gold and silver the ore in this vein carries, but a number of the assays that have been made gave results of from $10 to $15 in gold, and from 20 to 100 ounces of silver per ton.

The South vein is from 6 to 10 feet in thickness, strikes approximately N 57° W, dips to the southwest at angles ranging from 50° to 70°, and is composed mainly of quartz containing varying amounts of disseminated galena and chalcopyrite; the metallic constituents were nowhere noted, however, in sufficient quantities to constitute any considerable portion of the vein material. It is not known yet what this quartz assays.

The Rupert Group.

The Rupert group is owned by Messrs. Allan Rupert and James Johnson, and consists of eight claims located on the east face of Whitemoose mountain, which is situated on the west side and near the upper (south) end of Taku arm (Fig. 1). Five veins have been discovered on this property, and the float from a sixth has been found. The rock formation here is the same as on the White Moose property, and consists of the rocks of the Mt. Stevens group, largely the greenish amphibolite members, which are here highly schistose and much folded, mashed, broken, and metamorphosed. The veins appear all to be approximately parallel, and are best exposed on the mountain slope directly above, *i.e.*, to the west of Rupert's camp on the west shore of Taku arm. For convenience in description these veins have been numbered consecutively, beginning at the lowest and ascending towards the top of the mountain.

Vein No. 1 outcrops prominently in a gulch, at an elevation of 1,700 feet above Taku arm, strikes about N 80° W, and is from 2 to 3 feet in thickness. No. 2 vein lies about 300 feet, measured vertically, above No. 1, is from 6 to 8 feet in thickness, strikes N 73° W, and has a nearly perpendicular attitude. No. 3 vein is from 2 to 3 feet in thickness, outcrops about 70 feet above, and strikes and dips practically parallel with No. 2. No. 4 vein is approximately 950 feet above (measured vertically) No. 1, dips at high angles to the southwest, and is from 4 to 12

inches in thickness. Vein No. 4 appears to be about 4 feet in thickness, and to lie approximately 1,300 feet above No. 1, but it was only noted at one point, and the strike and dip could not be determined on account of the small extent of the outcrop. Nos. 1, 2, 3, and 4 are each traceable along the side hill for several hundred feet, have fairly persistent strikes and thicknesses, and appear to be similarly mineralized throughout. All consist mainly of quartz, which is prevailingly white and massive, although occasional vugs and bunches of vesicular crystalline quartz were noted, and in places the quartz is stained reddish with iron oxide. Galena is the prevailing metallic mineral present, and usually occurs sparingly distributed through the quartz gangue. Occasional particles of pyrite and native gold also occur. No. 2 vein is more heavily mineralized than the others, and in one place 6 feet of well mineralized ore occurs. The best specimens of native gold are believed to have been found in vein No. 4.

On the top of the hill above No. 5 vein, and lying along the northern edge of the glacier, are a great number of angular pieces of ore, some of which are as much as several hundred pounds in weight. This ore is different from that of the other veins, so far discovered on the hill, as the metallic minerals pyrite and galena are more abundant in it, and frequently exceed the gangue in amount; also pyrite is here the most abundant metallic constituent, whereas in the lower veins pyrite is of somewhat rare occurrence. A heavily mineralized vein of apparently considerable thickness must, therefore, exist under this glacier.

It is not known what amounts of gold or silver these veins contain, but assays running from $100 to $300 are claimed to have been obtained; however, it is probable that average tests would give results not exceeding a small portion of the smaller of these amounts. The property is on the lake front, very favourably situated for mining purposes, and the information that has been obtained concerning these claims appears to at least warrant further exploration and development.

The Lawsan Group.

General.—The Lawsan group is owned by Messrs. Fred Lawsan, Thos. Kirtland, Wm. Powell, Robt. Pelton, and Dan Sullivan, and Agnes A. Lawsan, and consists of six claims located on the west side of the valley of Bighorn creek, 10 miles distant, measured along the wagon road, from Kirtland on Taku arm (Fig. 1). This property was first staked in 1898, has since that time been owned by several parties, has lapsed twice, and was located by the present owners in 1909. The greater number of the veins that have been discovered are on the Bighorn claim, where all the development work has been done.

Geological Formation.—The rock formations on this group and in its vicinity, with the exception of occasional dykes, consist of the members of the Mt. Stevens group, of which the finely textured, greenish amphibolites predominate, and in these the mineral veins prevailingly occur; in addition, mica and sericite schists, as well as quartzites occur. Some of the Mt. Stevens rocks are in places quite fissile, and all are decidedly schistose, and have been folded, faulted, crumpled, and so metamorphosed that their original character has been masked, and in some cases entirely destroyed; they have also been invaded by numerous post-Palæozoic dykes of andesite, rhyolite, and the granite-porphyry. The formation in general strikes about N 15° E, and dips to the northeast at angles up to 15°.

The Veins.—The veins on this property are lense-shaped and are practically everywhere conformable to the foliation planes of the enclosing rock: no fissure veins intersecting the formation were noted. The lenses are divisible into two groups, formed at different times; of these the older veins were affected by pronounced dynamic activity before the newer ones came into existence. All the lenses are quite similar in their general appearance, and the two groups can only be distinguished in

the field by observing the faulting. The earlier veins are much more broken than the later ones, in fact although quartz veins and vein fragments are plentifully distributed throughout the formation in this vicinity, and outcrops from a fraction of an inch to several feet in width are everywhere to be seen, yet entire lenses more than a few inches in thickness, and 5 or 6 feet in length, are of rare occurrence. Some lenses are so faulted that one end only is removed; others are curtailed at both ends; and the original fragments have, in places, been again subdivided so that a considerable variety of forms result. One fragment 4 to 5 feet in thickness was noted that had lost both ends, and only a central portion 10 feet long remained. Another vein with an average thickness of 8 inches outcropped for 60 feet, and one end was complete and terminated in regular lense fashion, while the other end terminated abruptly, showing that an original portion was removed. Many lenses and lens fragments occur up to 20 feet in length and as much as 2 feet in thickness. A few lenticular veins occur, however, associated with those just described, that have been formed since the greater part of the faulting occurred, and so have been unaffected by these movements. The largest quartz lens noted was from 4 to 24 inches in thickness and over 200 feet in length; this is the vein on which the bulk of the work on the Bighorn claim has been performed.

The veins or lenses are composed of quartz which is in places rust-stained, and carries small amounts of galena, chalcopyrite, pyrite, and native gold. Some specimens were seen in which particles of gold existed, which were as much as 1/20 of an inch in diameter. In other places small flakes or leaves of gold were noted up to ½ of an inch across. Also, from the limited amount of prospecting and assaying that has been performed, it has been fairly conclusively demonstrated, for the Bighorn claim at least, that the gold only occurs in economically important amounts in the newer veins, and that the older more broken lenses are practically barren. The owners claim that the 200 foot lens will average $160 in gold and silver to the ton, the bulk of this amount being in gold.

Two tunnels 55 and 30 feet long, respectively, have been driven, and some open-cuts and trenches have beeen made. Also a temporary ærial tramway 1,700 feet long has been constructed to carry the ore from the tunnels down to the valley bottom. The British Columbia government constructed a wagon road during the past summer from the end of this tramway to Kirtland, on Taku arm, a distance of 10 miles, so that the properties are now quite accessible.

Other Bighorn Claims.

About 1½ miles north of the Lawsan group, and also on the western slope of Bighorn valley, at a point about opposite Peter's cabin (Fig. 1), a fissure-vein outcrops, which is traceable for a distance of at least 3,000 feet, and throughout this distance is remarkably persistent in dip, strike, thickness, and mineralization. This vein occurs cutting the schistose and gneissoid members of the Mt. Stevens group of rocks, has an average thickness of about 3½ feet, strikes N 56° E, and has an almost perpendicular attitude. The fissure filling consists almost entirely of quartz, throughout which are occasional particles of pyrite. This vein is remarkable for its persistency, and for the fact that it is the only fissure vein noted in this locality. The quartz is believed to carry a few dollars per ton in gold, but none of the known assays so far obtained have given more than $10 per ton in gold and silver.

At least two claims—the Birdie and the Gold Cup—owned, respectively, by Wm. Powell and Fred. Lawsan, are located on this vein, and on the Gold Cup two tunnels 85 feet and 160 feet in length, respectively, have been driven in on the quartz.

The Imperial Mines.[1]

The Imperial mines are owned by Messrs. T. H. Jones and James Stokes, of Atlin, and William A. Moore, of Nanaimo, B.C., and consist of four Crown granted claims, situated on the south side of Munroe mountain, 5 miles in a northwesterly direction from the town of Atlin (Fig. 1). This property was first located in 1899, and in 1900 was bonded to the Nimrod Syndicate of London, England, who surveyed and Crown granted the claims, built a five stamp mill and bunk house on the property, and did considerable development. At the end of a year this syndicate abandoned the property, and Mr. Herbert Pearce obtained an option on it for two years, 1901-2, since when no work has been performed on the property.

The rock formation at the Imperial mines appears to be nearly everywhere of a greenish, finely textured, volcanic rock that exhibits, in most places, considerable hornblende, and for convenience in the field has been given the indefinite name greenstone.

All the work on these claims has been applied to developing one main vein or lode, which strikes approximately N 70° E, dips from 50° to 60° to the southeast, contains, where it has been exposed, from 1 to 7 feet of vein material, and has been traced for a distance of over 500 feet. The vein is not simple in form, but consists, in most places, of quartz and associated minerals, which fill several close, parallel fissures; and also includes portions of the intervening wall-rock that have been altered by metasomatic replacement processes, and now consist, to a considerable degree, or entirely, of secondary ore materials. The vein is thus a compound vein, or since replacement has been effective to a considerable degree in altering the intervening and intercalated rock portions, the term lode is probably more appropriate.

On account of its compound nature this vein naturally varies considerably in thickness, and is also irregular in strike and dip. The main mineralized fault-zone which constitutes this lode is fairly persistent, but the various small included breaks are quite erratic, and in most places the lode is divisible into two or more distinct parts. In the upper tunnel on the property a rather typical section gives:—

—	Feet.	Inches.
Hanging wall		
Quartz, etc	2	1
Rock somewhat replaced	2	0
Quartz, etc	0	7
Rock considerably altered and heavily iron-stained	1	6
Quartz	0	7
Foot-wall		

Another section 30 feet to the northeast shows:—

—	Feet.	Inches.
Hanging wall		
Quartz, etc	2	0
Rock, heavily iron-stained and somewhat decomposed	2	7
Quartz, etc	1	1
Foot-wall		

[1] Report of the Minister of Mines, British Columbia, 1900, p. 777, 1904, p. G. 74, G. 76, G. 91.

The vein material appears to have an average aggregate thickness of from 2 to 3 feet, and consists mainly of quartz, which is often iron-stained or rose-coloured, and frequently exhibits crustification and comb structures, but is also in places quite massive in appearance. Sparsely distributed through the quartz are particles of galena, chalcopyrite, pyrite, malachite, and native gold. Pockets or shoots occur, however, in which these metallic minerals occur more plentifully.

In addition to this main lode, numerous other veins and stringers exist on the property, and the lower tunnel has cross-cut several fissures that contain from 6 to 8 inches of quartz and associated metallic minerals.

What average amounts of gold and silver this main lode contains are only approximately known, but a considerable portion of it probably carries from $10 to $30 per ton in these minerals. In 1902 a test sample of this ore, weighing 3,267 pounds net, was sent to Pellow-Harvey, Bryant, and Gilman, of Vancouver, B.C., who reported the ore to contain:—

Gold, 1·29 ozs. valued at $20 per oz..	$25 80
Silver, 1·26 ozs valued at $0·52 per oz..	66
Total..	$26 46

This firm also adds: 'The best method of treating this ore would be first to save the gold by amalgamation on the plates from a stamp-battery, and then cyanide the tailings, when a total extraction of about 97 per cent of the gold and silver contents should be saved.'

A mill-run, continued for several weeks by the Nimrod syndicate in 1900 upon the ore of this vein, gave, according to their published report, a little over $10 per ton in gold.

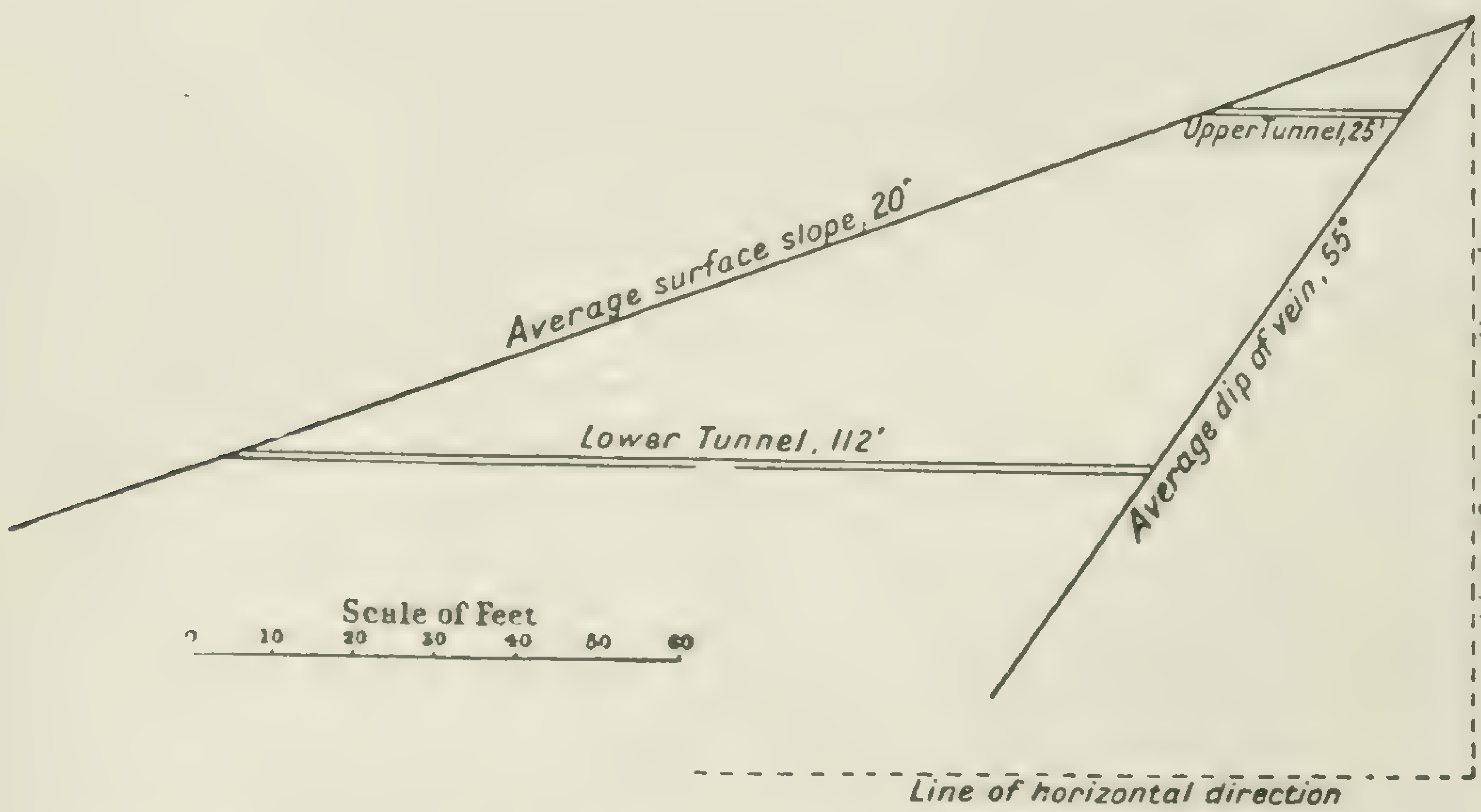

Fig. 3.—Section Through Working of Imperial Mines, Atlin Mining District, B.C.

The average slope of the south face of Munroe mountain is about 20°, and the vein dips in the same direction, but at an average of approximately 55°, so that the ore gradually gets farther from the surface of the mountain, but until the foot of the mountain is reached continues to be readily accessible by cross-cut tunnels.

Two cross-cut tunnels have been driven; the upper tunnel tapped the vein at a distance of 25 feet, and the lower one reached the ore in 112 feet. From the ends of these tunnels drifts have been driven in both directions, and 580 feet, in all, of underground work has been performed.

The entrance to the lower tunnel is 1,030 feet in elevation above the surface of Atlin lake at the wharf in Atlin, from which point there is a good wagon road to the

mines. Plenty of water is available at the base of Munroe mountain for crushing and milling requirements, and the falls on Pine creek nearby would afford ample power for any mining requirements.

This property thus possesses many natural advantages, and contains a considerable tonnage of ore which, although low grade, should yet prove workable by modern methods.

The Beavis Mine.[1]

The Beavis mine is owned by the Gold Group Mining Company, Limited, in which Messrs. H. Maluin and Wynn Johnson are the principal shareholders. This property consists of nine mineral claims, three of which are Crown granted, and is situated on the east shore of Atlin lake, 1½ miles north of the Atlin post-office. (Fig. 1.)

Several thousand dollars have been expended in the development of these claims, mainly on two shafts, which, when visited in October, were filled with water, so that no definite information could be obtained concerning their depth or the character of the ore deposit. From the material exposed on the dump, the rock in the shafts appears to be mainly black chert, and chert breccia, but a granite-porphyry dyke also cuts the formation in this vicinity. The ore apparently consists of a quartz vein carrying some pyrite and free gold.

Boulder Mountain Claims.

A number of claims have been located on the east slope of Boulder mountain, between Birch and Boulder creeks, about 12 miles in a northeasterly direction from Atlin (Fig. 1); of these the White Star group[2] of three claims owned by Captain Wm. Hawthorne, R.N., and the Lake View group[3] of three claims owned by Jos. Clay have been the most explored. Other claims between and adjoining these groups are also being held, and on some of them the same veins are supposed to outcrop that are found on the Lake View and White Star properties.

The formation in the vicinity of these claims consists of the members of the Mt. Stevens group of rocks, mainly the chloritic and sericitic schists, quartzites, and limestones.

On the White Star group two veins have been discovered; of these the upper one occupies a fissure in finely textured chloritic schists, is from 4 to 5 feet in thickness, strikes N 70° W, dips to the southwest at angles ranging from 80° to 85°, and outcrops at an elevation of 1,650 feet above the lower end of Surprise lake. This vein consists mainly of quartz, which is sparsely mineralized with galena, pyrite, and occasional particles of native gold. A tunnel 58 feet long has been driven on the ore.

Approximately 400 feet down the mountain slope from this upper vein is an exposure of quartz, across which a trench 30 feet long has been dug without coming to its edges, so that the dip, strike, etc., of this deposit are not known. The quartz contains occasional particles of pyrite and iron oxide, but has not been found to carry any other metallic minerals.

On the Lake View group two veins have also been discovered, that are about 400 feet apart and strike approximately in the direction of the White Star group. These are thought by the owners to be probably the same veins as those found on the White Star property, but sufficient work has not yet been performed to entirely justify this conclusion.

The upper vein on the Lake View group is from 3 to 4 feet, and the lower one is about 30 inches in thickness. The quartz of both is sparsely mineralized with

[1] Report of Minister of Mines, British Columbia, 1904, pp. G. 78, G. 91.
[2] Report of Minister of Mines, British Columbia, 1904, pp. G. 76, G. 77, G. 92.
[3] Report of Minister of Mines, British Columbia, 1904, pp. G. 76, G. 77, G. 92.

galena, pyrite, and rare specks of native gold. A tunnel over 150 feet in length has been driven, two shafts about 35 and 27 feet deep respectively have been sunk, and a number of trenches and open-cuts have been dug on this group of claims, with the result that the two veins thereon have been traced for several hundred feet.

A few samples have been obtained from these Boulder Mountain deposits that assayed from $100 to $300 per ton, and one or two are claimed to have given even higher results, but an average of the veins would probably not exceed $10, and might be somewhat less. From the various tests that have been made, however, it is hoped that a considerable portion of the quartz will pay for mining when such can be done economically. Further, in all probability, other veins will yet be discovered in this vicinity, as the mountain is in many places covered with a mantle of superficial materials that hide the bed-rock and whatever ores it contains.

The Laverdiere Group.

The Laverdiere group is owned by three brothers, Messrs. Noel, Frank, and Thomas Laverdiere, and consists of six claims, three of which are Crown granted, and two fractional claims. This property is situated on the west side of Hoboe creek, about 2 miles from where it runs into West bay, which forms the upper end of Torres channel, an arm of Atlin lake. (Fig. 1.) The principal ore body on the Laverdiere group, or at least the one most highly valued and that on which the bulk of the development has been expended, is described under 'Contact Metamorphic Deposits.' In addition, two fissure veins have been discovered on the Alvine and Brothon claims, respectively, that appear from the limited amount of work that has been performed on them to belong to the gold-silver quartz veins, and so will be here described. It is possible, however, that they would be more appropriately classed under high-grade silver veins.

The vein on the Alvine claim strikes approximately N 30° W, has an average thickness of about 2 feet, and occurs in the Coast Range granitic rocks. This deposit consists almost entirely of a gangue of quartz, which is in most places somewhat stained with iron-oxide, and with which is associated a small amount of white calcite. Disseminated through this gangue is, nearly everywhere, more or less argentiferous tetrahedrite (grey copper containing silver) and in addition, small particles and flakes of native silver also occur. It is not known what this ore will assay, but its general appearance warrants the expenditure of sufficient work to thoroughly explore the vein.

On the Brothon claim another mineralized fissure occurs in the Coast Range granitic rocks, which strikes N 85° E, has an almost vertical attitude, and can be traced from near the level of the valley bottom several hundred feet up the mountain side. In places, this fissure includes between its walls several inches of quartz which is associated with some calcite, and contains more or less galena and tetrahedrite, and also occasional particles and flakes of native silver. Near the valley this fissure includes only about one-fourth of an inch of decomposed clayey material, through which and the somewhat altered and replaced walls for 6 to 14 inches on each side of the fault, is a certain amount of disseminated argentiferous tetrahedrite, and native silver. Assays of the mineralized wall-rock have been obtained that gave results as high as 600 ounces, and it is claimed that a zone 12 to 14 inches in thickness, bordering the fissure, will average from 20 to 30 ounces of silver per ton.

CUPRIFEROUS SILVER-GOLD VEINS.

Table Mountain Claims.

The Petty Group.—The Petty group is owned by Mr. Ira Petty, and consists of two claims which are situated on the southeastern corner of Table mountain, overlooking Graham inlet, and are about 3½ miles in a northwesterly direction from Taku Landing (Fig. 1).

The rock formation in this vicinity consists mainly of the Chieftain Hill volcanics, which are here prevailingly greenish andesites and andesitic tuffs. These have been extensively invaded by dykes of granite-porphyry, belonging to the Klusha intrusives.

The ore all occurs in the granite-porphyry and exists mainly in the form of fissure veins, but also includes more or less mineralized and replaced wall-rock. Only one main vein has been so far exploited on the Petty group, and this strikes N 30° E. and has an average dip of about 40° to the northwest. The vein consists mainly of quartz, calcite, galena, chalcopyrite, pyrite, malachite, and azurite, and one small cavity was found to be lined with small crystals of the rare mineral linarite (a basic sulphate of lead and copper). The quartz is generally rust stained, and occurs associated with varying amounts of calcite, which in places even exceed the quartz in amount. Galena and chalcopyrite are the most abundant ore minerals present, and occur in approximately equal amounts, and in sufficient quantity in places to constitute the greater portion of the vein material. This vein has a thickness, at the widest point so far discovered, of about 2 feet, but rapidly diminishes to 6 inches or less within a distance of 50 feet in each direction, and has not been followed for over 100 feet. It is possible, however, that further development may show the vein to extend a somewhat greater distance. In addition, several other mineralized fissures occur in places on both sides of this main fissure, and within distances of 1 to 2 feet from each wall; and the rock between these is, to some extent, replaced and impregnated with various ore materials; so that at the main shaft the ore might be considered to have a total thickness of 3 feet at the surface, but towards the bottom of the shaft its thickness is much less. The ore is claimed to contain $4 or $5 per ton in gold, with the main values in silver and copper; but so few tests have been made, that it is uncertain what average amounts of these metals the ore carries.

An inclined shaft 90 feet deep has been sunk on the ore, commencing at the most promising point on the surface, and within 50 feet an open-cut has been dug. A trail has been made from the shore up to the workings, which are about 1,200 feet in elevation above, and directly overlooking Graham inlet.

The Dundee Group.—The Dundee group is owned by the British Crown Gold and Copper Mining Co., of Victoria, B.C. This Company was incorporated November 29, 1909, with a capital of $1,000,000, and with Mr. Scott I. Wallace, of Seattle, Wash., as secretary-treasurer, and Messrs. W. W. Felger, F. G. Holder, A. C. Pellissier, and Wm. F. Howe as directors. The property consists of two adjacent claims, one of which, the Dundee, adjoins the Petty group to the northeast, in the supposed direction of strike of the Petty vein (Fig. 1). The formation on the Dundee group is the same as on the Petty claims, and the ore also occurs associated with a granite-porphyry dyke. Only one vein has been developed on this property, and this strikes N 30° E, dips to the northwest at 40° to 50°, is lens shaped, and for 10 or 15 feet has a thickness ranging from 1 to 2½ feet. Thirty feet to the northwest from this point of greatest thickness at the surface, the vein is not more than 1 inch thick, and it cannot be traced more than 20 feet to the southwest. It has been supposed that this is the same vein as that on the Petty group, as both strike in the same direction; however, there appears to be no support for this assumption, as the vein on the Dundee claim distinctly terminates within 100 feet, at most, of the places where it outcrops, in the direction towards the Petty claims; this is clearly evident from the fact that the rocks are all well exposed in a draw 100 feet from the outcrop of the Dundee vein, in a direction towards the Petty shaft, and although any vein crossing this draw would be easily seen, none is to be found. Further, if the vein continued from the Petty shaft in the line of strike it there maintains, it would pass considerably above the showing in the Dundee claims.

The Dundee vein is similar in appearance to that on the Petty group, and consists of a quartz and calcite gangue, highly impregated with galena, chalcopyrite,

malachite, and azurite. The wall-rock also contains a considerable amount of these minerals disseminated through it. Instead of following a fissure in the central portion of a granite-porphyry intrusion, however, as in the Petty group, the vein here continues near the edge of a granite-porphyry dyke, but was nowhere seen to depart from this rock into the surrounding andesitic materials.

Two tunnels, having respectively lengths of approximately 20 and 150 feet, have been driven on the Dundee claims, neither of which has cross-cut the vein; and in addition two small open-cuts have been dug. A trail has been constructed from the shore of Graham inlet up to the higher of these workings, which is about 700 feet above and directly overlooking the water.

The Pelton Group.—The Pelton group is owned by Mr. R. L. Pelton, of Taku Landing, and consists of two claims, which adjoin the Dundee group in the direction of the general line of strike of the vein on that property (Fig. 1). The rock formations on the Pelton claims are the same as on the Petty and Dundee groups, but no ore has been encountered as yet.

SILVER-LEAD VEINS.

Veins on Crater Creek and Vicinity.

General.—When visited in October, 1910, about a dozen claims were held on Crater creek and in the vicinity, and of these, those on which the most development has been performed, and which exhibit possibly the most promising showings, constitute the Big Canyon group of four claims, which were located in 1899 and are owned by Messrs. John Malloy, Thomas Vaughan, and M. Summers. Mr. S. Johnson also owns several claims in this locality (Fig. 1).

The formation in the vicinity consists mainly of a coarsely textured, light coloured, granitic rock, which, in many places, is porphyritic, and contains feldspar phenocrysts often exceeding an inch in length. This formation has been extensively invaded by dark green, finely textured, andesitic dykes, which are everywhere in evidence. The ore deposits as a rule occur entirely within the volcanic intrusives, but in a few places were observed to lie at the contact between these and the granitic rocks, and, in all cases, seem to be genetically related to the dykes.

Big Canyon Group.[1]—Two main mineralized dykes or veins occur on the Big Canyon group; of these, one crosses the right branch of Crater creek possibly 300 or 400 feet above, and the other meets the main creek a short distance below the forks of the creek.

The upper dyke strikes N 40° E, dips 80° to 85° to the northwest, has an average width of about 30 feet, and is traceable on the surface for at least several hundred feet. This dyke, where exposed and explored on the left bank of the creek, is roughly divisible into three portions of about equal thickness. The upper third has been subjected to repeated faulting, and now consists predominantly of brecciated fragments cemented together mainly with infiltrated quartz, there being an increasing proportion of cement as the central portion of the dyke is approached. The upper edge of the dyke thus consists mainly of rock, which decreases gradually until at a distance of about 10 or 12 feet there is a predominance of vein and ore materials.

The middle third of the dyke contains the bulk of the ore, which occurs in the form of one or more fissure veins, including numerous narrow veinlets, and in irregularly-shaped bodies, bunches, etc., which occur between and replacing the breccia fragments. Metasomatic replacement is here very clearly and vividly illustrated, as breccia fragments can be found in all stages of transition, from those consisting entirely of original rock materials, to others formed altogether of secondary ore and vein matter, with generally the original shape of the fragments still preserved. Galena

[1] Report of Minister of Mines, British Columbia, 1900, pp. 760, 778, 779.

and arsenopyrite (arsenical iron pyrite) are the prevailing ore minerals, but pyrite, zinc blende, and ankerite[1] also occur. In addition to these minerals, a certain amount of quartz and calcite, and more or less altered dyke rock occur, constituting the gangue of the ore. In places, however, almost no quartz or calcite are present, and in one of the tunnels in this dyke a body 4 feet in thickness, composed almost entirely of galena, was noted.

The lowest 10 feet of the dyke has been here but slightly affected, but lying along the foot-wall is a vein of ore about 1 foot thick, composed mainly of galena, arsenopyrite, and altered dyke rock.

The lower of the two main ore-containing dykes on the Big Canyon group strikes N 40° E, dips at angles from 80° to 90° to the northwest, is traceable for at least 3,000 feet and possibly considerably farther, and is, wherever seen, from 8 to 15 feet wide. This dyke, in a general way, much resembles the upper one just described, but here no distinct zones or persistent bands were noted, and the ore varies in position from place to place along the vein, but appears generally to be best near the foot-wall. From 4 to 12 feet of this dyke is heavily mineralized, mainly with galena, zinc blende, and arensopyrite, but pyrite, as well as chalcopyrite (copper pyrite), also occurs. Here also the ore occurs filling various fissures and irregular cavities, and forming numerous narrow veinlets; and also exists in irregular bodies, bunches, particles, etc., replacing the original dyke rock. Constituting the cavity fillings is a considerable amount of quartz and calcite, which are almost entirely absent where metasomatic processes have been prevailingly effective.

In addition to these two main bodies, a number of small veins, generally a few inches in thickness, were noted, which possess the same general appearance and characteristics that distinguish the larger deposits.

In the deposits on the Big Canyon group, as well as those elsewhere in the vicinity, both the filling of cavities, including fissures, and the replacement of the original rock, have been instrumental in producing the ore deposits; but, of the two processes, the latter appears to have been the more effective.

A most striking feature in connexion with these deposits is the persistency with which the faulting and subsequent mineralization adhere to the andesite dikes. In one place a fault, or rather a fault zone, was followed for over 3,000 feet, and for the entire distance it remained confined to a dyke that nowhere exceeds 15 feet in width; and at no point, though it might almost be expected to do so, does the fracturing extend into the granitic rocks on either side. This phenomenon is apparently due to one or both of two causes. In the first place there appear to be a number of old, well-defined lines of weakness in the formation in this locality, and at the time of the andesitic intrusion the main dykes followed these, and since that time the various stresses to which the earth's crust has been here subjected have found relief along the same lines. It may also be that the dyke materials are more brittle, and less resistant to the forces that have here been active than the granitic rocks, and that on this account mainly, the fractures have been confined to the dykes. Whatever the cause, it is evident that faulting has been active along these definite lines for a long period, commencing before the andesitic intrusion, and continuing possibly to the present time, but at least until long after the bulk of the ore and vein materials was deposited in the faulted and brecciated dykes, since more recent veinlets were discovered cutting portions of the deposits in practically their present condition.

The ores of the two larger deposits on the Big Canyon group contain only a small amount of gold, generally under $4 per ton, but they are believed to carry more important amounts of lead and silver. It is not known definitely how much of these metals the ores contain, but from the information obtainable it is thought that they

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[1] $CaCO_3$, + (Mg, Fe, Mn) CO_3, or a dolomite in which magnesia is more or less completely replaced by protoxide of iron, or of iron manganese.

are decidedly low grade, but that they occur in quantities holding sufficient lead, silver, and gold to make them worthy of careful exploration and investigation.

On the upper vein two tunnels have been driven, the lengths of which could not be determined on account of ice which they contained, but they probably have an aggregate length of over 100 feet. A shaft, possibly 40 or 50 feet deep, has been sunk on the lower vein, and several open-cuts and shallow pits have been dug. Two cross-tunnels have also been commenced, which have, however, not yet tapped the ore. There are, in addition, a number of open-cuts, trenches, etc., on this property.

Other Deposits.—Crossing Crater creek at a point about 300 feet in elevation below where the upper vein on the Big Canyon group crosses the right fork, is a dyke which strikes N 27° E, dips from 80° to 90° to the southeast, and is about 5 feet in thickness. Where this dyke is exposed on the right bank of the creek, about 2 inches of ore occurs on the hanging wall; and on the left bank of the creek, where the ore is claimed to be considerably thicker, a short tunnel has been driven, which when visited had so caved in that the hanging wall side of the dyke was not visible. The ore seen was very similar to that in the Big Canyon veins.

At approximately 1,500 feet in an easterly direction from the showings on the Big Canyon group on Crater creek another dyke occurs, which is about 6 feet in thickness, strikes N 40° E, and has an almost perpendicular attitude. This dyke has been subjected to faulting and brecciation until it is now composed almost entirely of rock fragments, more or less cemented with quartz, calcite, galena, arsenopyrite, and zinc blende. In places the secondary minerals constitute about half the filling between the granitic walls. A shaft about 10 feet deep has been sunk on this material.

Besides these, a number of similar, and promising deposits of ore are believed to occur in the vicinity, but on account of the lateness of the season, and the prevailing stormy weather, they were not examined.

COPPER VEINS.

Copper veins were noted in Atlin district in only one area, which includes the southwestern corner of Copper island[1] and the adjoining small islands in Atlin lake (Fig. 1). Several claims were held here for a number of years by the Laverdiere brothers, but were allowed to lapse during the year 1910. The formation consists of reddish and bluish, prevailingly coarsely textured basalts and tuffs, of which the tuffs predominate, and in places consist almost entirely of basic volcanic fragments, but grade into rocks containing a predominance of sedimentary materials.

A number of veins, from a fraction of an inch to 6 inches in thickness, and composed mainly of calcite and disseminated particles of native copper, intersect these basalts and tuffs. The veins consist in most places mainly of calcite, but pieces of copper weighing several pounds each are occasionally found in them. Associated with the native copper are malachite (common green copper stain), and occasionally cuprite (red oxide of copper), and tenorite (black oxide of copper). Copper also occurs, both in small disseminated particles and collected along the various seams adjoining the veins.

ANTIMONY VEINS.

Antimony veins were noted in Atlin district at only one point, which is situated on the west shore of Taku arm about 10 miles below (north of) Golden Gate. Two claims, the Lakefront and Antimony, have been located here by Messrs. J. Johnson, and C. B. Dickson (Fig. 1) respectively.

The ore occurs in the form of bedded veins that conform in a general way to the stratification planes of the enclosing rocks, which here lie almost flat, and consist mainly of the dark, finely textured, clay-shale members of the Jura-Cretaceous, Laberge series.

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[1] Report of Minister of Mines, British Columbia, 1904, p. G. 80.

The main vein is from 3 to 4 feet in thickness, and is composed chiefly of quartz and stibnite (antimony sulphide), with also some galena, and includes, as well, varying amounts of intercalated shale. In some places the entire 3 or 4 feet is composed of vein materials, but in others, beds of shale occur separating the layers of quartz, and constitute about one-half the entire material, which is, in a general way, regarded as the vein or ore body. The quartz is generally quite heavily mineralized.

In addition, a number of bedded veinlets, ranging in thickness from a fraction of an inch to 2 or 3 inches, occur within a few feet of the upper edge of this vein.

A drift about 15 feet in length constitutes the bulk of the development on this deposit.

CONTACT METAMORPHIC DEPOSITS.

General.

Contact metamorphic deposits of economic interest have been found in the Atlin district in only one locality, which is situted on Hoboe creek, near the upper end of Torres channel, an arm of Atlin lake (Fig. 1).

The valley of Hoboe creek has an average width of about half a mile, is flat, and contains numerous, swampy meadows, which are the result, to a great extent, of beaver dams at different points on the stream. Schists, quartzites, limestones, etc., of the lower Palæozoic (?) Mt. Stevens group apparently underlie a considerable portion of this valley, and, for a distance of approximately 2 miles from Torres channel, extend up its western slope as well. Adjoining these rocks on the west are the Coast Range granitic intrusives, which constitute the high, steep sided hills to the west and south. The contact metamorphic ore deposits are included in the Mt. Stevens rocks near their contact with the granitic intrusives.

Along this contact, the Laverdiere and the Callahan groups of claims have been located.

The Laverdiere Group.

The Laverdière group is owned by three brothers, Messrs. Nöel, Frank, and Thomas Laverdière, and consists of six claims, three of which were located in 1899 and have been Crown granted, and two fractions. In addition to the contact deposit which is here considered, two mineral veins have been discovered on this property, and are described above under gold-silver veins. The main workings on this property are situated on the western edge of the valley of Hoboe creek, 1½ to 2 miles from the mouth of the stream.

The Mt. Stevens rocks which outcrop along the western edge of the valley consist prevailingly of finely textured, chloritic and greenstone schists, and limestone. Cutting these, and lying to the west and southwest of them, are the Coast Range granitic intrusives, which are prevailingly light grey or pink, coarsely textured, granodiorites. The ores prevailingly occur in the older rocks and near their contact with the intrusives.

The ore deposit is at one point approximately 150 feet in thickness, and wherever a section of the rocks immediately below the granitic intrusives has been seen, at least 30 to 40 feet of ore material has been found; this consists mainly of magnetite, chalcopyrite, tetrahedrite (grey copper), malachite, cobalt bloom, and various altered gangue materials including considerable biotite. Typical samples of these ores were supplied to Mr. R. A. A. Johnston, mineralogist, of the Geological Survey, who states: 'These specimens consist of an association of magnetite, chalcopyrite, and occasional small amounts of tetrahedrite, with altered gangue material made up of mixed carbonates and silicates of indefinite composition. The more important minerals in these specimens are sometimes sufficiently well segregated to admit of

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[1] Report of Minister of Mines, British Columbia, 1904, pp. G. 79, G. 80.

easy recognition, but in general they are so intimately mixed with each other, and with the gangue materials, that they can be separated only with very great difficulty; these mixtures are so intimate at times as to at first sight present a homogeneous aspect; this intimacy of mixture not only affects the appearances of the different constituent minerals but it also has the effect of greatly modifying the tarnish colours produced through oxidation; this applies particularly in the case of chalcopyrite, which tarnishes to a brownish colour and presents almost the appearance of some pyrrhotite.'

The best showing of ore is perhaps on the French claim, on which a cross-cut tunnel 188 feet long has been driven, of which more than 130 feet are in ore. Numerous faults, having displacements generally of only a few inches or a few feet, were encountered in the tunnel, with the result that in several places blocks of rocks were found adjoining others composed of ore.

The rocks that are altered and replaced appear to have been mainly the chloritic schists; the limestone has for the greater part suffered merely crystallization and marbleization. The ore extends up to within a few feet of the contact, which is about 50 feet in elevation above the valley. A few hundred feet up the valley from the French tunnel, the contact and its associated ore, by persisting in their southeastely strike, extend from the hillsides out into the valley-flat and are here lost to view, but probably again outcrop on the hills to the southeast.

The ore in the French tunnel assays from 1·65 per cent to 6 per cent copper, and it is thought that a considerable portion of it will average between 2 per cent and 4 per cent.

On the Holy Cross claim a tunnel 35 feet long has been driven, but has not yet reached the ore. Above here, however, a body 40 feet in thickness, composed almost entirely of granular magnetite, occurs. This iron ore contains a certain amount of chalcopyrite, and malachite, as well as cobalt bloom, which occurs disseminated through the ore in places, and also frequently coats weathered surfaces. The ore here, as on the adjoining French claim higher up the valley, extends up the hillside to within a few feet of the contact between the schistose and granitic rocks, which is about 55 feet above the valley. The ore in the Holy Cross tunnel does not contain as much copper as in the French tunnel, and does not, probably, average more than 1 per cent. All the ore on the Laverdiere group is reported to contain small amounts of silver and gold.

The Callahan Group.

The Callahan group (Fig. 1) is owned by Mrs. Callahan, and consists of six claims, which adjoin the Laverdiere group and extend in a northerly direction to the upper end of Torres channel, known as West bay. The contact between the Mt. Stevens' rocks and the Coast Range intrusives passes through these claims, but is in most places concealed by superficial materials, and by the forest growth; where it is exposed, however, ore occurs in its vicinity much resembling that on the Laverdière property. These contact deposits have not been developed, however, and the assessment work has been performed on various quartz veins, generally lens-shaped, that occur mainly in greenish schistose rocks, and are prevailingly only a few inches but in places are as much as 6 feet in thickness, and show generally only a small amount of pyrite. It is claimed that these veins contain also native gold.

COAL.

Sloko Lake Claims.

In 1908 Mr. Alex. McDonald was informed by Indians of the occurrence of float coal near the southeastern summit of Sloko mountains, and at a point to the northeast of and overlooking the lower (east) end of Sloko lake. Since then ten claims

have been located in the vicinity, by Alex. McDonald, Norman McLeod, James Johnson, M. A. Dickson, J. Dunham, M. Wynn Johnson, David Gibb, E. Lambert, N. C. Wheeling, and Samuel Johnson. Seven of these claims are now owned or controlled by the Amalgamated Development Co., of Vancouver, B.C.

The rocks outcropping along the shores and on the hills overlooking the lower end of Sloko lake from the north are mainly lavas and tuffs belonging to the Wheaton River volcanics, and are prevailingly greyish to yellow in colour, except where stained by iron oxide. Occasional basaltic dykes pierce these materials, but do not comprise any considerable portion of the general formation. The volcanic flows and beds still lie nearly flat, and outcrop horizontally along the walls of Sloko Lake valley, giving rise to numerous successive benches or terraces forming broad steps up the mountain slopes. These rocks weather and decrepitate rapidly, giving rise to an abundance of talus, which in turn decomposes readily to form a fine ash-like material. The mountains are consequently, in most places, rugged and precipitous, and the scenery is wild and imposing.

The Wheaton River rocks extend to the east down the valley of Sloko river, the outlet of Sloko lake, for approximately 2 miles, where sedimentary rocks belonging to the Jura-Cretaceous Laberge series outcrop, and thence continue down the valley for several miles at least. The Laberge beds occur also on the mountain slopes on the north side of Sloko river, where they extend to an elevation of 2,550 feet above Sloko lake at their most northwesterly exposure, and 2½ miles in a northeasterly direction from the northeastern corner of the lake.[1] Here only a narrow tongue of these rocks has been stripped by erosion and weathering processes of their original cover of volcanics, and is still surrounded, and overlain on three sides, by flat-lying beds, which hide the remaining portions of the Laberge rocks to the north, east, and west.

The sedimentary beds, where exposed, strike about N 70° W, dip to the southwest at from 20° to 50°, and consist mainly of dark, finely textured shales and sandstones, but also include near the summit of the ridge some dark conglomerates that belong to the Tantalus conglomerates, and consist entirely of quartz, chert, and slate pebbles, generally firmly cemented together. All the important coal seams that have been found in northern British Columbia and southern Yukon occur associated with these Tantalus conglomerate beds.

The uppermost portion of this sedimentary area just described is, in most places, covered by several feet of weathered and decomposed material, which is derived from the surrounding and underlying volcanics and sediments, predominantly from the volcanics, and is in the form of sand, mud, and clay; this in places contains a certain amount of wash coal, which occasionally occurs in layers more or less mixed with other products of erosion and weathering, and near the summit of the ridge, pieces of lignitic coal and carbonized wood, as much as 6 inches thick, have been found. Some of the layers of detrital coal were at first thought to be coal seams in place, but the fallacy of this idea soon became apparent.

When visited in the latter part of September, 1910, the seams from which the float coal is derived had not been discovered, but a small amount of work should expose them. The pieces of coal found are lignitic in character, and would make a good fuel. The utilization of this coal, when found in place, will be difficult, owing to the fact that it is situated on a mountain top high above timber-line and in an almost inaccessible portion of the district. An attempt should be made to trace the seams, when uncovered, to the more accessible country to the east or southeast, in the valleys of Sloko river or its tributaries, where it might pay to mine the coal, if found in clean seams of sufficient thickness.

[1] The level of Sloko lake on September 25 was approximately 230 feet above that of the upper end of Atlin lake.

Other Coal.

Coal is to be expected wherever the Tantalus conglomerates occur, especially where any considerable thickness of these beds remains. The south side of the lower end of Sloko lake, and along Sloko river, are very probable localities that should be carefully prospected.

Tantalus conglomerates were found on an inconspicuous summit on the south side of Graham inlet, about 5 miles southwest of Taku Landing, but only about 30 feet of the bed remain, as the overlying portions have been removed by erosion; however, it is probable that more of the conglomerates occur farther to the south and southwest where the accompanying coal seams should also be found. This probability almost reaches a certainty, from the fact that small pieces of coal are reported to have been found during the past season in one of the creeks running into the north side of Graham inlet.

A piece of solid, firm coal, apparently bituminous in character, and weighing possibly 20 or 30 pounds, was brought to Atlin by prospectors, and placed on exhibition in the Gold Commissioner's office. This sample is reported to have been obtained from a 4 foot seam on Taku river, 12 miles above canoe navigation, and about 30 miles from Juneau.

PORTLAND CANAL DISTRICT.

(R. G. McConnell.)

The season of 1910 was spent in studying the geology and ore deposits of the Portland Canal district. I was assisted by Mr. A. O. Hayes in the geological examination, while Mr. Malloch collected data for a topographical map.

The work was greatly hampered by the lack of a suitable topographical map on which to lay down the geological boundaries, and further field work will be necessary before a correct geological map can be issued. A sketch map compiled as carefully as the existing conditions permitted has been prepared to accompany this report.

Previous Work.—While no work had previously been done by the Geological Survey in the district, three reports have been published by the British Columbia Bureau of Mines. Two of these, by Mr. H. Carmichael, Provincial Assayer, are included in the annual reports of the Bureau of Mines for 1906 and 1909 respectively, and one by Mr. W. F. Robertson, Provincial Mineralogist for British Columbia, was published during the past season as Bulletin No. 2, 1910.

Acknowledgments.—The writer is indebted to most of the mining men in the district for information and other courtesies, and especially to Mr. C. M. Dickie, president, Mr. Elmendorf, manager, and Mr. Sheridan, mine superintendent of the Portland Canal Mining Company; Mr. A. Erskine Smith, president, and Mr. Webster, mine superintendent of the Red Cliff Mining Company; Mr. A. D. McPhee, manager of the Red Cliff Extension and other mining companies; Mr. H. B. Williams, engineer for the Lordigordy Mining Company, etc.; Mr. Vaughan-Rhys, engineer for the Main Reef Mining Company, etc.; Mr. Tuomy, mine superintendent of the Stewart Mining and Development Company; Mr. Knobel, manager of the Pacific Coast Exploration Company; Mr. Smith, manager of the International Portland Mining Company; Mr. Baxter, mine superintendent of the Main Reef claim; Mr. James Lydden, part owner of the Old Chum and other claims; and Mr. Anderson of the Black Bear group.

SITUATION AND COMMUNICATION.

The district is situated in northern British Columbia, close to the Alaska boundary, at the head of Portland canal, one of the largest of the numerous fiords which indent the North Pacific coast. Portland canal cuts completely across the long granitic batholith which forms the central portion of the Coast range and reaches the mineralized sedimentary and intrusive rocks which border the batholith on the east. Bear river empties into the canal at its head, and the area examined includes the portion of the mineralized belt drained by that stream and its tributaries.

Portland canal is a large deep inlet, easily navigable by the largest steamers. Stewart, the distributing point for the district, is situated at its head, and several steamship lines maintain regular communication between it and Prince Rupert, Vancouver, and other coast towns.

A wagon road has been built by the Provincial Government, from Stewart up Bear River valley to Bitter creek, a distance of about 10 miles, and from it the principal showings are reached by trails constructed partly by the Government and partly by private companies. A railway up the valley is now being built.

DISCOVERY.

The metalliferous character of the Portland Canal mining district was first discovered by a party of prospectors in 1898, the year of the great Klondike rush. They were searching for placer deposits, but failing to find pay gravels turned their attention to prospecting for quartz. The Roosevelt and other claims on the North fork of Bitter creek were staked in 1899, and the Mountain Boy and American Girl on American creek in 1902. The Alaskan boundary at that time had not been defined, and the claims were first staked under United States laws, but were subsequently restaked and recorded in British Columbia. The Red Cliff, which could hardly escape the notice of prospectors as the croppings show up prominently on the mountain side, was first staked in 1898, and has lapsed and been restaked several times, the last time in 1908.

While some prospecting and staking were done year by year, little actual mining work was attempted until 1907, when the Portland Canal Mining Company commenced development work on the Little Joe and Lucky Seven claims on Glacier creek. The success met with drew the attention of miners to the district, and during the last three or four seasons, prospectors have swarmed over it, and little ground from Stewart far up Bear River valley, which shows any signs of mineralization, is now left unstaked. Only a few of the claims have been even roughly prospected, and on only two, the properties of the Portland Canal and the Red Cliff Mining Company, is development work much advanced. A number of companies, however, commenced systematic work during the past season.

TOPOGRAPHY.

The Portland Canal mining district is situated in the heart of the Coast range, in a region of intense glaciation, and its topography, while still bold and striking, has been toned down by moving ice, and much of the original ruggedness removed. It has been heavily glaciated up to a height of fully 5,500 feet[1] above the sea, and the mountain slopes, below this level, although usually very steep, often rising in sheer unscalable cliffs, are, as a rule, comparatively smooth, except where scored and broken by narrow cañons carved out, in post-glacial times, by streams plunging down from the perennial snow and ice fields above.

The district embraces a number of high mountain groups and mountain ridges, separated by the deep valleys of Bear river and its numerous tributaries, but usually coalescing around the heads of these streams.

The principal mountain divisions include the long, rather even ridge separating Bear river and its tributary American creek from the Salmon; a group of mountains between American creek and the upper part of Bear river; a range of high sharp peaks known as the Cambria range[1] bordering the upper part of Bitter creek; a broken ridgy group culminating in Mt. Gladstone between the north fork of Bitter creek and Bear river, and a group of high, snow covered, rather flat topped elevations between Bitter and Glacier creeks, for the highest point of which the name Mt. Dickie[2] is proposed.

The long ridge west of Bear river has a general elevation of about 5,000 feet, but is surmounted by occasional irregularly distributed rocky peaks, some of which attain a height of over 6,000 feet. One of the most prominent of these, situated nearly opposite the mouth of Bitter creek, is known as Mt. Dolly. The sharp-crested, angular-peaked Cambria range, the wildest portion of the district, rises in places to elevation of over 8,000 feet, and Mt. Otter, the highest point, to an elevation of 8,800

[2] Name proposed by miners interested in the vicinity.
[3] After the President of the Portland Canal Mining Company.

feet. Mt. Gladstone, the highest point in the range bordering the upper part of Bear river on the south, has an elevation of 6,800 feet, and Mt. Dickie, between Glacier and Bitter creeks, an elevation of nearly 6,600 feet. The snow covered mountain group of which Mt. Dickie forms the centre is exceedingly precipitous on the Bitter Creek side, but falls away in easier slopes towards Bear river and Glacier creek.

The dominant features of the mountain landscape, viewed from one of the higher elevations, are the steep valley slopes, the jagged peaks of the Cambria range, and the prevalence above an elevation of 4,500 feet of vast fields of snow and ice. These either terminate in long lines of ice cliffs from which huge masses are constantly falling, or form glaciers which descend the mountain slopes for some distance, and are then replaced by roaring torrents often deeply hidden in rocky cañons.

Drainage.—The district is drained entirely by Bear river and its tributaries. Bear river is a swift mountain stream about 18 miles in length. It heads with a branch of the Nass in a glacier, which flows northward to the Pass from a peak in the Cambria range, and is then diverted by the mountains bordering the Pass on the north, westward down Bear river and eastward down a branch of the Nass. The tongue flowing down Bear river has a length of about three-fourths of a mile. The one flowing towards the Nass is reported to be somewhat longer.

The Pass is comparatively low, the elevation at the foot of the glacier, measured with the aneroid, being approximately 1,370 feet, and the ice divide at the summit, 2,100 feet.

Bear river in the lower part of its course, below Bitter creek, is a wide, winding stream, flowing rapidly in a net work of channels around gravel bars and low islands, which are being constantly built up and destroyed. The valley is a deep, steep-sided, flat-bottomed typically ice worn trough, practically a continuation of the Portland Canal depression, partially filled up with gravel and silt.

Above Bitter creek, Bear river is more confined, and its valley, while still wide, becomes more irregular. Rough benches, covered in places with moraine material, occur along the sides, and occasional rocky spurs extend part way across it. Between American creek and the summit the valley bends to the east, becomes much narrower, and at one point passes into a cañon, known as the Bear River cañon. The valley bottom above the cañon is usually from 200 to 500 yards in width, and is lined in places with low gravel terraces. A small lake, filling the valley, interrupts the course of the stream a mile below the termination of the summit glacier.

The principal tributaries of Bear river are Glacier and Bitter creeks from the east, and American creek and an unnamed stream near its head from the north.

Glacier creek is a short, rapid stream, from 20 to 50 feet in width, formed by three glacier fed branches. The trunk stream has a length of 2½ miles, and is sunk in a deep narrow cañon throughout its whole course.

Bitter creek joins Bear river 8½ miles from its mouth, and is the largest stream entering it, probably carrying more water at ordinary seasons than the main river. It has a length of 6 miles to its main source in the Great Bromley glacier, and a fall averaging 100 feet to the mile. It is a wild stream, the swift current and boulder strewn channel making it practically one long rapid. The valley is narrow, except near the mouth and in the vicinity of the North Fork, and in places is badly blocked in the early part of the season by snow slides.

Four miles above Bitter creek, Bear river bends to the east, and is joined by a large branch from the north, known as American creek, the two forks being nearly equal in size. Only the lower portion of American creek was examined. It is longer than Bear river, and is fed by numerous glaciers, one of which, about 7 miles above its mouth, crosses and blocks the valley.

A fourth large tributary joins Bear river 1½ miles below the summit glacier. It is a short stream issuing from a large glacier, and flows more water than Bear river above the junction.

Besides the large tributaries referred to, the mountain sides are furrowed everywhere by a multitude of roaring torrents cascading down the steep slopes, and few places in the district are free from the sound of falling water.

Glaciers.—The uplands of the district, except on the steep slopes, are largely covered, above an elevation of from 4,500 to 5,000 feet, with permanent fields of ice and snow. These form numerous glaciers, which fill the upper part of most of the valleys of the district and creep down the mountain slopes for varying distances; few of them reaching the main valley bottoms and most of them terminating at elevations of from 2,500 to 4,000 feet above the sea.

The largest glacier in the district is the Bromley[1] glacier, at the head of Bitter creek. This is formed by several branches, originating in large snow fields situated east of the area examined. One branch sweeping southward, skirts the base of Mt. Trevor,[1] a beautiful snow covered peak rising high above the icy plain at its base, and is reported to head with a glacier descending Marmot river. Only the lower 5 miles of the glacier were mapped. In this stretch it has a width of from 4,000 to 5,000 feet, and fills the valley of Bitter creek from side to side. The slope is irregular and averages about 700 feet to the mile. The surface, while rough in places, especially near the sides, is not badly crevassed, and the glacier is easily ascended for several miles. The Bromley glacier descends to an elevation of less than 1,000 feet, the lowest level reached by any of the glaciers of the district.

Other prominent glaciers occur on the North fork of Glacier creek, the North Fork of Bitter creek, at the head of Bear river, and at numerous points along Bear river, and American creek.

All the large glaciers are receding slowly up their valleys. This is shown by fresh moraines, both terminal and lateral, left behind in the retreat, and by the absence of vegetation for some distance below the present terminations. The Bitter Creek valley below the Bromley glacier is bare for a distance of over half a mile.

FOREST.

All the valley bottoms of the Portland Canal district are well wooded, and the forest sweeps up the mountain slopes, except where cleared away by snow slides, to heights of from 3,500 to 4,500 feet, depending on the exposure. Stunted specimens of balsam and mountain hemlock were found at an elevation of 5,000 feet.

The principal tree in the valley bottoms and lower slopes of the mountains is a hemlock (*Ptsuga mertensiana*). It is a fair-sized tree, usually attaining a diameter of from 2 to 4 feet, and furnishes excellent mining timber. The Sitka spruce (*Picea Sitchensis*), which usually accompanies the hemlock, is a tall stately tree, some specimens seen measuring fully 6 feet across. The cottonwood (*Populus Trichocarpa*) and a large alder (*Alnus Oregona*), are well represented along the flats. The yellow cedar (*Chamaecyparis nootkatensis*) occurs in a few places in the district, but no specimens of the red cedar were seen. On the higher slopes the trees mentioned above are replaced by balsam (*Abies Amabilis*), and the mountain hemlock (*Ptsuga Heterophylla*).

The forest is protected from destructive fires by the humid climate, and the timber resources are sufficient to meet the requirement of the district for many years.

FAUNA.

Only a few species of animals thrive in the district. The mountain goat is abundant in places, and it, with the black bear, the siffleur, an occasional wolf, the

[1] Name proposed by mining men interested in Bitter creek.

marten, and mink are the principal representatives of mammalian life. The heavy winter snowfall is probably responsible for the absence of the deer and other species usually common along the coast.

CLIMATE.

The situation of the Portland Canal district on the west slope of the Coast range, though some distance inland, places it within the rainy belt, and the precipitation, while not so excessive as in the outer ranges, is still very high, probably averaging well over 100 inches per year. The best weather occurs as a rule in the late spring and early summer months. The past season was exceptional in this respect, dry weather continuing well into September. The precipitation falls as rain in the valleys from early in April until near the end of October, and as snow during the rest of the year. The temperature is equable, as the summers are cool and in the winter the thermometer seldom drops much below zero.

Heavy snow slides, due to the excessive winter snowfall and the steep slopes, are common throughout the district in the late winter and spring months. These usually follow the valleys, but in places plunge directly down the mountain sides, destroying the forest in their course. At some of the mines and prospects the slides are at times a serious menace.

WATER-POWER.

Large streams with steep grades, most of them fed from permanent ice and snow fields, are available for water-power in every part of the district. At the present time only Glacier creek is being utilized, although plants at several other points are projected.

General Geology.

The rocks and rock formations represented in the Portland Canal district are classified tentatively as follows, in order of relative age:—

1. Glacial deposits.
2. Basic dykes.
3. Felsitic dykes.
4. Coast Range granitic rocks.
5. Diorites (?).
6. Nass formation (tuffs, agglomerates, etc.).
7. Bear River formation (complex series of greenstones).
8. Bitter Creek formation (dark argillites).

No fossils were found in the district, and the age of the formations is uncertain. The last three are cut by granitic rocks and felsitic dykes, and are, therefore, older than the Coast Range batholith usually referred to late Jurassic.

BITTER CREEK FORMATION.

The Bitter Creek formation consists of a series of dark argillaceous rocks, well exposed on Glacier and Bitter creeks. It is the oldest formation in the district and economically the most important.

Distribution.—The Bitter Creek slates and slaty rocks are separated from the granitic rocks of the Coast Range batholith by the Bear River greenstone formation. They appear from beneath the greenstones on Glacier creek half a mile above its mouth, and are exposed in almost continuous sections to its head, except where cut by intrusives. They cover most of the region between Glacier and Bitter creek, and extend north of Bitter creek to Mt. Gladstone, near the limit of the area examined.

Rocks.—The Bitter Creek formation is very uniform in composition, consisting almost entirely of dark and dark grey, often iron-stained argillites. On Bitter creek and other places they have a striped appearance, due to the alternation of fine-grained, dark and coarse greyish layers. They are highly altered, and in places pass into lustrous, mica schists. Slaty cleavage is well developed in some sections, while in others the principal partings follow the original bedding planes.

The argillites include at rare intervals beds of dark grey, finely crystalline limestones, and occasional thin, greyish feldspathic bands, probably tufaceous in origin.

Structure.—The Bitter Creek argillities have a northwest-southeast strike, approximately parallel to the eastern edge of the Coast Range batholith, and dip in a southwesterly direction towards it. This applies both to the original bedding where observable, and to the subsequent slaty cleavage. The dips are low along the western edge of the area, but become steeper going eastward, and in the Mt. Gladstone ridge the inclination often approaches verticality.

Faulting on a small scale was observed in places, but no evidence of great breaks or overturns affecting the whole formation was obtained.

Economic Features.—The Bitter Creek argillities are traversed by numerous quartz veins or silicified zones, usually conforming very closely to the dip and strike of the enclosing rocks. Large, persistent veins, well mineralized in places with metallic sulphides, occur south and north of Glacier creek, on Bitter creek, and in other places. The veins often parallel felsitic dykes at a short distance, and are occasionally in contact with them.

BEAR RIVER FORMATION.

This name is applied to a series of altered greenstones lying east of the granitic mass of the Coast range and apparently overlying the Bitter Creek argillites.

Distribution.—The great ridge west of Bear river is formed almost entirely of the rocks of this formation, north of the granite contact. They also cross the Bear River valley and occur on the lower slopes of the elevations east of the valley. The rocks in the group of mountains between Bear river and American creek, and in the mountains bordering Bear river above the mouth of American creek, although differing in some respects, are included in it provisionally.

Rocks.—The rocks of the Bear River formation consist mostly of greenstones, differing greatly in character and often altered into schists. They probably represent an old volcanic complex. The principal rock in the ridge west of Bear river below American creek is a massive, rather fine-grained greenstone, usually destitute of phenocrysts. It resembles a diorite in hand specimens, but has not been examined microscopically, and probably consists partly at least of altered fine-grained tuffs. Dark, hard argillaceous rocks are associated with it in a few places, and coarse, altered agglomerates, holding faintly outlined fragments, occur occasionally in the higher slopes of the Bear River ridge.

Ascending Mt. Dolly opposite the mouth of Bitter creek, the fine-grained greenstones are largely replaced above an elevation of 4,000 feet by a variety sprinkled with feldspar crystals. This porphyritic variety is often reddish in colour and is traversed by numerous small, branching, reddish veinlets, not conspicuous in the compact green variety outcropping below.

Northward along the ridge the porphyritic variety becomes more important, and descends in places nearly to the level of the valley. It is irregular in its distribution, and often alternates with and passes gradually into the even-grained green variety.

In the mountains between American creek and Bear river the same varieties are represented, but the proportion of agglomerates is increased, and bands of dark slates, and slates and limestones occur at a few points. At the south end of Bear River cañon a greenstone variety with augite phenocrysts covers a considerable area.

The rocks of the Bear River formation are altered occasionally by silicification into cherts. Large cherty areas occur north of Lydden creek at an elevation of about 4,000 feet, and on the slopes of the mountains bounding Bear river on the south above the Bear River cañon. A red coloured mountain, east of the Bromley glacier 3 miles above its termination, is formed almost entirely of cherts. The cherts here are filled with iron pyrites in grains, and the conspicuous coloration is due to their surface decomposition. The definite classification of the original rocks in this area awaits further study, as they differ in some respects both from the Bear River and Bitter Creek formations. They are dark coloured but are coarser textured than the Bitter Creek argillites, and include fragmental bands.

Structure.—The Bear River formation, although known to be partly at least of fragmental origin, is practically massive throughout. It is schistose in a few places, especially in the valleys, but bedding or banding, except where infrequent dark argillaceous bands are included, is seldom observable. The original massive, and fine and coarse fragmental constituents, have been compacted and altered by the granitic invasion and the processes of mountain building into a massive formation, often nearly homogeneous except for slight differences in texture, through sections 3,000 feet to 4,000 feet in height.

Economic Features.—The Bear River formation is well mineralized. The deposits occur frequently in the form of lenses or irregular shaped areas, often of large size. The principal mineral in these is usually pyrite, occasionally pyrrhotite. The iron sulphides are accompanied by subordinate and varying amounts of chalcopyrite, blende, and galena. The gold and silver values are often important.

Veins filled with quartz, and fissured zones with the country rock partially replaced by various sulphides are also common.

NASS FORMATION.

The Nass formation overlies the massive greenstones of the Bear River formation. It consists of red, green, grey and dark tufts, agglomerates, slates, and shales, all well bedded, with occasional massive porphyritic bands, probably representing flows. It has a limited distribution in the district, occurring only near the summit of the ridge separating Bear river and American creek from the Salmon. Two areas were seen, one of limited extent south of Lydden creek, and the other exposed only on points projecting through the snow which covers the ridge north of Lydden Creek valley. Outside the immediate Portland Canal district its areal extent must be considerable. It occurs, resting on the Bear River greenstones and dipping northwestward at a moderate angle, in the summits of the mountains north of the Bear River-Nass divide, and eastward towards the Nass; and the drift brought down by the Bromley, Bear River summit, and Salmon River glaciers, and scattered along the valleys, consists mostly of the rocks of this formation.

No mineral deposits of importance have so far been discovered in the rocks of the Nass formation in the district.

DIORITES (?).

A fine-grained greenstone, resembling a diorite in hand specimens, intrudes the slates of the Bitter Creek formation in a rounded area about 1½ miles in diameter at the head of Glacier creek. A second area, also intruding slates, was traced from the glacier at the head of the North fork of Bitter creek, southward in a generally narrowing band across Hartley gulch to the Bromley glacier.

The rocks in these areas resemble some of the greenstones of the Bear River formation, and may possibly be of the same age. They are badly altered, too much so, in the few sections examined, for specific determination, but are nowhere crushed into schists.

The Glacier Creek occurrence is cut by numerous moderate sized veins, mostly siliceous in character but occasionally containing a calcite or siderite filling. They are well mineralized in places with pyrite, galena, blende, chalcopyrite, tetrahedrite, stibnite, and other minerals. Promising veins also occur in the area east of Bitter creek, especially in the vicinity of Hartley gulch.

GRANITIC ROCKS.

The eastern edge of the Coast Range granitic batholith crosses the western angle of the district examined, and granitic rocks form the mountains bordering the lower portion of Bear river on the west. The boundary of the batholith has a general northwest southeast direction, but is irregular in detail. Near the mouth of Bear river it bends southward, forming a large spur, which crosses Bear River valley and extends for some distance into the mountains east of the valley.

Granitic outliers in the form of rounded areas and long dyke like masses are common throughout the district. A long area, over half a mile wide in places, was traced from Mt. Dickie northwesterly down the valley of Bitter creek, and across the great ridge bounding Bear river on the west to the Salmon River valley. On Goose creek, and at the head of Lydden creek, this area is represented in part by a succession of wide parallel dykes. Numerous smaller areas occur in the ridge west of Bitter creek, in the mountains between Glacier and Bitter creek, and north of the lower part of Bitter creek.

The granitic rocks vary widely in mineral composition. In the main area, the principal rock is a greyish, medium grained granodiorite, with biotite as the principal dark mineral. Two of the outlying areas are gabbroic in character, and varieties occur ranging from this basic type through quartz diorites, acid granites, and quartz porphyries, to an acid siliceous rock scarcely distinguishable in hand specimens from a quartzite. Quartz porphyries, with numerous rounded quartz grains and occasionally some feldspar phenocrysts scattered through a felsitic ground-mass, are common both in dikes and areas.

The granitic rocks, while fractured and mineralized at a few points, are not so important economically as the Bitter Creek and Bear River formation.

FELSITIC DYKES.

The grey felsitic dykes which are formed everywhere in the district cutting the Bear River, Bitter Creek, and Nass formations are generally connected with the granitic rocks, and were intruded during, or possibly in some cases immediately after the granitic invasion. They generally follow more or less closely the bedding or cleavage planes of the sedimentaries, but in places cut directly across them. They are usually large, often 30 feet or more in thickness, and traceable for long distances. On Bitter creek, especially along the southwest side of the Bromley glacier, a succession of large grey dykes, alternating with the dark argillites of the Bitter Creek formation and running nearly horizontally along the steep valley walls, forms a conspicuous feature of the landscape.

The dyke rocks are usually medium grained, and occur both in a granular and porphyritic condition. In composition they resemble the granitic batholithic rocks, but are probably more acid, as the dark ferro-magnesian minerals are seldom present in quantity. A light coloured quartz porphyry is a common variety.

The felsitic dykes are often paralleled at a short distance by mineral veins, and occasionally are in contact with them.

BASIC DYKES.

The youngest rocks in the district consist of a widespread system of dark greyish, brownish-weathering basic dykes. These cut all the older formations, up to and

including the various granitic varieties. They are smaller than the felsitic dykes, seldom exceeding 6 feet in width, and are also finer grained and darker coloured. They have not been studied microscopically, but probably, judging from hand specimens, mostly belong to the diabase group.

The basic dykes are not mineralized, except by scattered grains of iron pyrite, and were intruded after the main era of mineralization. In many instances they cut directly across veins and ore bodies without noticeable effect on either themselves or the deposit intruded.

GLACIAL DEPOSITS.

Below Bitter river the accumulations of the Glacial period in Bear River valley are buried beneath alluvial gravels, silts, and sands. Above Bitter creek the main valleys are generally floored with boulder clays and loose morainic material. The deposits are very irregular in thickness, and in places have been destroyed and carried away by the rapid streams. Clay beds cover an area about a mile in length above Bitter Creek valley. They were evidently laid down in a glacial lake, formed by the extension of the Bitter Creek glacier across Bear River valley.

On the mountain slopes occasional moraines, formed during halts in the recession of the great glacier, occur up to a height of 5,000 feet, while scattered erratics were found up to an elevation of 6,000 feet.

ECONOMIC GEOLOGY.

The Portland Canal district is remarkable for the widespread character of the mineralization it has undergone. This is manifested not only by the number of concentrated metalliferous deposits of varying sizes scattered throughout the region, even though these are so numerous that practically the whole district has been staked, but also by changes in and additions to the principal rock formations themselves. Secondary iron pyrite is everywhere present, and silicification on an unusually large scale has taken place. Large areas—in one instance a whole mountain mass—have been altered by this process into hard cherty rocks.

The district is situated immediately east of the great group of granitic rocks which form the central portion of the Coast range, and its mineralization is doubtless due to this fact. During the granitic invasion, the neighbouring rocks, both sedimentary and intrusive, were intruded by dykes, crushed and broken and rendered permeable to emanations, probably mostly in the form of siliceous waters from the cooling magma. These were either originally charged with the various metals, or leached them out in their passage through the various rocks encountered and deposited them when heat and pressure lessened.

The whole district is probably underlaid in depth by granitic rocks, as dykes and stocks are numerous everywhere.

CLASSIFICATION.

The deposits of the district may be generally grouped into two classes:—

1. Veins (mostly quartz).
2. Irregular, replacement deposits.

Quartz Veins.—The quartz veins occur mostly in the Bitter Creek argillites, but in some instances were found traversing the massive Bear River greenstones. In the argillites they follow, in most cases, long zones of fissuring and crushing, often of considerable width, which while enlarging and pinching at intervals along the strike, are on the whole fairly regular. The walls are straight and well-defined in places, in others ragged and irregular. The quartz filling varies greatly in purity in different veins and along different portions of the same vein. Fragments of the broken coun-

try rock are almost invariably present in some quantity, and in places the vein consists of alternating bands of quartz and argillite, or of a brecciated mass of argillite cemented together by quartz. In some instances the line of the vein is marked only by stringers and lenses of quartz distributed irregularly through the argillites.

The veins, with few exceptions, have a general northerly trend, approximately parallel to the direction of the eastern edge of the neighbouring granitic batholith and to the strike of the enclosing argillites. The dip is usually westward towards the granite at angles varying from 20° to nearly vertical.

While most of the veins are comparatively small, usually from 2 to 4 feet in width, a number are exceedingly strong and very persistent. The most notable of these is the vein on which the Portland Canal Company's mine is situated, south of Glacier creek. This vein, while it cannot be continuously followed, as some stretches are concealed and others are inaccessible, is traceable by a succession of outcrops, some of considerable length, all following the same general direction for a distance of over 2 miles, and probably extends across Glacier creek to the Sunbeam claim, a total distance of nearly 4 miles. The quartz filling may be interrupted in places, but it is practically certain that the line of disturbance is continuous. In places several parallel veins are present. The width of the vein is commensurate with its length, ranging from 10 feet to over 60 feet, and probably averaging 20 feet in the outcrops seen. The strike of the vein is northerly, and the dip is westerly at low angles, usually about 30°.

North of Glacier creek, the O.K., Portland Wonder, George E, and other claims are situated on veins following a line of strong fissuring, traceable for over a mile. On the George E, four well-defined veins, the largest 27 feet in width, occur in the fissured zone. These veins are usually considered to be a continuation of the vein, or series of veins south of Glacier creek, but this, while probable, is not altogether certain, as the outcrops are separated by a concealed interval about half a mile in length. The dips in the veins north of Glacier creek are also somewhat steeper, and the direction is more easterly.

Other large quartz veins occur on Bitter creek south of the Bromley glacier.

The principal metallic minerals in the large quartz veins are pyrite carrying gold values, silver bearing galena, zinc blende, and occasionally notable quantities of native silver. Pyrite is always the most abundant mineral present, and in portions of the veins is often the only one. Where it occurs in masses it is usually associated with subordinate quantities of galena, and some blende.

While practically only a beginning has so far been made in the exploration of the large quartz veins, enough has been done to show that the distribution of the metallic contents is extremely irregular. The veins are seldom entirely barren, and small bunches of ore are common, but concentrations large enough and rich enough to be of commercial value are rare. One such deposit is now being worked by the Portland Canal Mining Company, and others may be discovered as exploration proceeds. Several promising portions of the veins are now being investigated.

Small and medium sized veins, that is, veins ranging from a few inches to 6 feet in width, and occasionally even wider, are very common in the Bitter Creek slates, in the dioritic area at the head of Glacier creek, and also occur, though less frequently, in the Bear River greenstones, and in the granite. Some of these veins are very persistent, one on the Middle fork of Glacier creek having been traced across three claims, and one on Hartley gulch for over 1,000 feet. Few of them have been explored sufficiently to determine their extent.

The gangue in the smaller veins is more varied than in the larger ones. Quartz is nearly always present, and a few of the veins consist entirely of that mineral. Others have calcite as the principal gangue, or a mixture of calcite and quartz, and occasionally the filling consists mostly of siderite.

The metallic content also show greater variation. In the dioritic area at the head of Glacier creek tetrahedrite in grains, bunches, and small lenses occurs in some of the veins, associated with galena, pyrite, blende, and stibnite. Lenses and stringers of nearly solid galena occur in veins at Bear River cañon, and at points east of American creek. Chalcopyrite, in bunches and lenses, usually accompanied by pyrite, blende, and galena, also occurs in a few croppings.

The small veins, like the larger ones, are, as a rule, irregularly mineralized, shoots of ore, usually short, alternating with barren or comparatively barren stretches, and the bunchy character of the mineralization has already led to some disappointments. Very few of the veins, however, have had any considerable amount of work done on them, and a large number, some with promising outcrops of good ore, still await investigation.

Replacement Deposits.—In the massive and slightly schistose greenstones of the Bear River formation, the ore deposits occur characteristically in irregular, often ill-defined masses. A number of red patches, due to the oxidation of these masses, are plainly visible from the valley in the mountain slopes bordering Bear river and American creek. The shapes are very variable, some are wide and blunt, others rounded or elliptical, and a few are elongated, resembling wide irregular veins. In some of their features these mineralized areas resemble contact metamorphic deposits, but the characteristic contact metamorphic minerals, such as garnet, epidote, augite, etc., which invariably accompany such deposits, are never present in quantity, and are usually altogether absent. Garnet, mostly in disseminated crystals, was seen at only two of the croppings visited.

The gangue in these deposits is mostly the more or less altered country rock, although some quartz is usually present, and in places there is a considerable development of this mineral. Calcite and barite also occur, but are less common.

The deposits probably always occur in connexion with lines of fissuring, or. as suggested by their irregular outlines, with broken areas, but this is not always evident. In some of them the relationship is plain, as they are bounded on one, or sometimes on both sides by fissures, and for portions of their courses, especially where the replacement is nearly complete, resemble and practically are veins. Traced farther, the space between the so-called walls becomes less well mineralized, and often passes into ordinary country rock. Transitions occur from this vein like type, through occurrences partially bounded by walls, to others wholly lacking in definite boundaries other than those afforded by the gradual disappearance of the replacing minerals.

The metallic minerals in the replacement deposits are generally similar to those in the veins, except that pyrrhotite is occasionally present in place of pyrite. The proportion of chalcopyrite is probably greater on the whole, and the proportion of galena less.

Pyrite, often carrying significant gold values, is usually the principal mineral present. The pyrrhotite is always, as far as known, low grade. The associated minerals are chalcopyrite and galena in varying quantities, and usually a little blende. The chalcopyrite at the Red Cliff ore body, the only member of this class of deposits on which much development work has been done, is distributed in grains, bunches, and interbanded with pyrite through the whole mass of the lode, and forms a considerable percentage of it. In most of the occurrences examined the copper and lead sulphides are present only in portions of the pyritized area, and in some are apparently absent altogether.

The ultimate value of these large mineralized areas cannot safely be predicted, a number of them are inviting enough to warrant exploration, while others are hopelessly low grade, on the surface at least.

MINERALOGY.

The following list includes the most important minerals so far identified:—

Gold.—While no specimens containing free gold were collected by the writer, it is reported, on good grounds, to occur in a quartz vein crossing the Ruby claim now being developed by the Portland Bear River Mining Company. The vein in places assays high in gold. Free gold is also stated to occur in a yellowish quartz vein, from 4 feet to 10 feet in width, on Gold Bar No. 1 claim, south of Bitter creek, but was not positively identified.

Native Silver.—Native silver in small blebs and plates enclosed in quartz, and in thin flakes and scales along partings, occurs in places in the workings of the Portland Canal Mining Company, the Stewart Mining and Development Company, on the O.K. claim, and in other places. There is reason to believe that the silver is, partly at least, an original constituent of the ores. It often occurs in solid quartz, associated with iron and other sulphides which have undergone no change of any kind.

Iron Pyrite.—This is the most abundant mineral in the district. It occurs in some quantity, and is usually the principal mineral present in all the showings, both in the argillites and greenstones. It also occurs in grains disseminated through most of the rocks of the district. Its gold content is usually important, and in places high assays for gold have been obtained from it. The silver value is also important in places.

Pyrrhotite.—Pyrrhotite occurs in veins and large irregular masses in the greenstones, but is seldom found in veins cutting the argillites. Its tenor in gold is usually low.

Arsenopyrite.—Arsenical pyrites occurs in some of the veins, but is not common.

Chalcopyrite.—This mineral is widely distributed in the district, and at the Red Cliff mine constitutes a considerable proportion of the lode. It occurs in veins and lenses in the greenstones, in veins in the granite, and occasionally in veins cutting the argillites. Except at the Red Cliff no large body has so far been found.

Bornite.—Bornite is reported to occur on the Rangoon, a claim not examined by the writer.

Malachite and Azurite.—The copper carbonates are conspicuous in some of the deposits as stains and incrustations, but do not occur anywhere in quantity.

Galena.—Lead sulphide is one of the important minerals of the district. It is found in some quantity in most of the deposits, its usual associates being pyrite, zinc blende, and occasionally chalcopyrite. Veins or narrow lenses of nearly solid galena, a few inches in thickness, occur in the Bonanza, Independence, and a number of other claims. Most of these appear to be short.

The galena, besides its lead content, always holds appreciable values in silver. The tenor is variable, ranging from a few ounces to over 100 ounces per ton.

Sphalerite.—Zinc blende is widely distributed in the district, accompanying iron pyrite and galena. The percentage present is usually small, but in some instances, notably on the Ajax, is considerable. The discovery of workable zinc deposits is not improbable.

Stibnite.—This mineral is not common. Specimens were obtained from the Silver King claim and it is also reported to occur in the Mountain Boy.

Tetrahedrite.—This rich silver mineral, commonly known as grey copper, occurs in grains, bunches, and small lenses, in some of the veins cutting the greenstone area at the head of Glacier creek. The principal occurrences are now being investigated.

Argentite.—Argentite is reported to occur at a number of points, but was not positively identified. Specimens shown as argentite proved on examination to be thin plates of tarnished native silver.

Anthraxolite.—This dark carbonaceous mineral occurs in small quantities in a quartz vein on Bitter creek, and also on a claim in the Salmon River district.

GANGUE MINERALS.

Quartz.—Quartz is the common gangue mineral of the district, and in the slates is often the only one present. It occurs in numerous veins in all the formations of the district, and also, though less prominently, in the irregular replacement deposits characteristic of the Bear River formation. Large areas of country rock have also been silicified.

In the veins the quartz filling is often marked by long lines of interlocking crystals, and in places a concentric arrangement of the crystals around fragments of country rock, and occasionally around metallic grains is a prominent feature.

Calcite.—Coarse crystalline calcite occurs in some quantity in most of the deposits, and in a few of the smaller veins is the principal vein filling.

Siderite.—Siderite is not common as a gangue mineral, but occurs as the principal filling in a vein traversing the Silver King and Evening Sun claims on the Middle fork of Salmon creek.

Barite.—Veins of nearly pure barite a few inches in width occur on the Waratah claim, high up on the slopes of Mount Dolly. It also occurs as a gangue mineral in the Mountain Boy lode on American creek, and in other showings in the vicinity.

Garnet.—Garnet is rare in the camp, occurring, so far as known, only in small quantities on two claims, both in the Bear River greenstones.

Chlorite.—A bright green chloritic mineral is a conspicuous constituent of the veins on the George E, O.K., and other claims north of Glacier creek. It occurs in blotches and narrow bands up to half an inch in width, following lines of quartz crystals. The bands are occasionally straight for short distances, but usually follow wavy courses, and in many cases circle round fragments of slate and other impurities enclosed in the quartz vein filling.

This mineral is usually spoken of in the camp as a silver chloride, but is referred by Mr. R. A. A. Johnston, who examined a number of typical specimens collected by the writer, to the chlorite group. It appears to be an original constituent of the veins.

Chlorite, sericite, and other micaceous minerals occur largely as decomposition products in the replacement deposits of the Bear River greenstones.

Hornblende.—Secondary hornblende occurs in a few places in the deposits in the Bear River greenstone, but is not prominent.

Main Features of Some of the Principal Mines and Prospects.

CLAIMS ON GLACIER CREEK.

Portland Canal Mining Company.

This Company, under the management of Mr. W. J. Elmendorf, M.E., has been engaged for some time in exploring a group of claims near Glacier creek, and has succeeded in finding and partially outlining what is at present the most important known ore body in the camp.

Situation.—The Lucky Seven and Little Joe, the two claims most developed, are situated south of Glacier creek about 2 miles east of Bear river. The country slopes

steeply up from Bear river and Glacier creek, and at the workings (lower tunnel) has an elevation of 2,453 feet above sea-level.

Geology.—The Glacier Creek basin is occupied principally by the dark coloured Bitter Creek argillites, described on a previous page. Near the mouth of the creek they are replaced by the Bear River greenstones, and between the South and North forks are intruded by an important diorite mass. The argillities are seldom contorted or crumpled except in the vicinity of the vein, and have a fairly regular westerly dip. The general strike is a few degrees west of north.

Vein.—The vein explored forms part of a long fissured and silicified zone traceable for over 2 miles, which follows the upper part of Glacier creek on the east and continues up the South branch. At the workings the fissured zone has a width in places of over 30 feet. It is irregularly silicified, and consists of quartz often filled with metallic sulphides and usually holding fragments of slate, alternating with partially silicified and unaltered slates, and brecciated slates cemented by quartz. Usually there is a persistent central quartz mass from 2 to 6 feet in width, bordered on both sides by small quartz lenses and veinlets which diminish in size and frequency outwards. The boundaries are occasionally definite walls, but similar walls often occur in the interior of the vein, and simply mark subordinate lines of fissuring. Ordinarily the limits are known only by the disappearance of the quartz. Following the strike the proportion of quartz in the vein varies greatly. The amount present is doubtless a measure of the completeness of the fissuring and shattering suffered by the slates in any particular part and the relative ease with which they were infiltrated and replaced by the ore-bearing solutions.

The dip of the vein is westerly, and is comparatively low, somewhat less than 30°. The strike is about 25° west of north. Both dip and strike conform closely to that of the enclosing argillites.

Workings.—The vein outcrops on a steep hill side, and has been opened up by three tunnels driven along the strike of the vein. The drifts wind considerably, a witness to the difficulty experienced in following the ore in the wide, gently dipping lead.

The upper or No. 1 tunnel has a length of 190 feet. It follows a practically continuous ore body for a distance of 100 feet, beyond which the sulphides which carry the values occur in a condition too disseminated to constitute commercial ore.

No. 2 tunnel is situated 110 feet easterly along the vein from No. 1, and has a length measured along its curving course of 180 feet. A narrow band of ore was followed from the portal for a distance of 30 feet. A low grade stretch of 30 feet succeeds this, beyond which good ore was encountered and followed for 60 feet. A second waste stretch 30 feet in length occurs at this point, after which ore reappears, and continues to the present breast of the tunnel, a distance of about 35 feet.

No. 3 tunnel, 170 feet northeasterly along the vein from No. 2, is much the longest of the three, but shows the least ore. It has a total length, following the bends, of nearly 500 feet. Owing to the contour of the surface, the vein outcrops considerably east of the probable extension downwards of the ore bodies found in the upper tunnels, and no ore is exposed for the first 140 feet, and no large continuous body until near the end. The last 40 feet, and the face, were in ore at the time of my visit, and the vein for some distance before reaching the ore body contains disseminated sulphides in considerable quantities. Ore also occurs in a short cross-cut to the south 150 feet from the portal, and in a second cross-cut to the east 120 feet farther on. The extent of these ore bodies is still unknown.

No. 3 tunnel is connected with No. 2 by an upraise 65 feet in length, on a slope of 45°, and an upraise from No. 2 to No. 1 was under construction when the mine was examined.

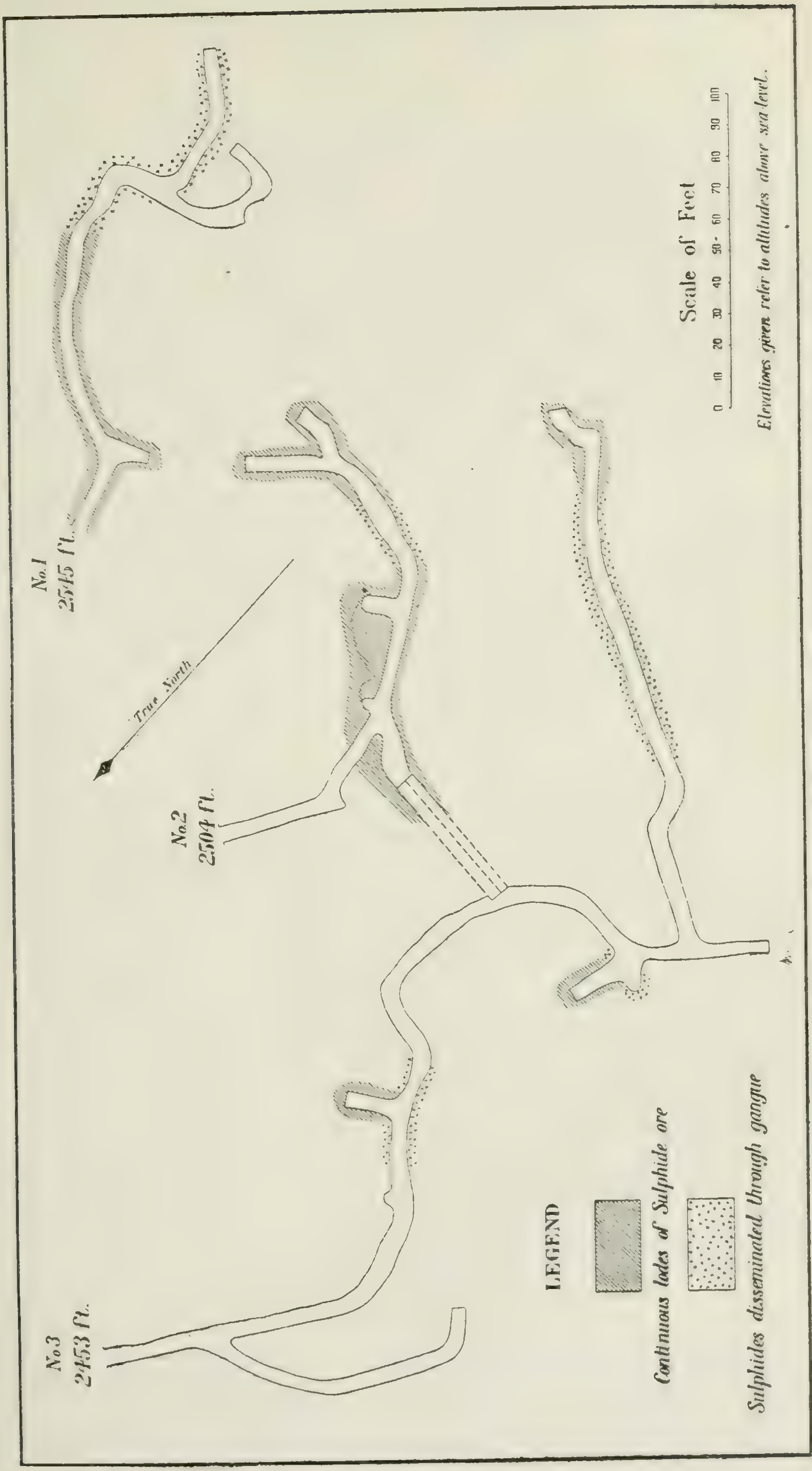

Fig. 4.—Plan of Workings of Portland Canal Mine, from Surveys by Management—Sept. 15, 1910.

Ores.—The Portland Canal ores consist mainly of auriferous pyrite, associated with varying but much smaller quantities of silver bearing galena, some blende, and in portions of the vein a little native silver, most of which appears to be primary. The galena at times is interbanded with the pyrite, but as a rule is scattered somewhat irregularly through it in grains and small bunches. The sulphides, while occasionally occurring in almost solid masses, are usually scattered more or less densely throught a siliceous, sometimes a slaty matrix. Fragments of slates are also frequently enclosed in the ore. The values are mainly in the sulphides, and when the proportion of sulphides present drops below a certain point, difficult to estimate but probably somewhere between 10 per cent and 20 per cent, the vein ceases to be profitable.

The ore shows little oxidation and secondary minerals are uncommon.

Ore Bodies.—The ore body or bodies—as probably more than one is present—extend beyond the present development work, and are still imperfectly outlined. The ore occurs in flattened masses, usually from 2 feet to 6 feet, but occasionally 8 or 10 feet in thickness, and probably averaging about 4 feet. The masses never occupy the full width of the vein, and while fairly regular in their extension, occasionally jump along cross fissures to higher or lower positions in it.

In No. 1 tunnel a practically continuous ore body has been followed for 100 feet. The two lower tunnels enter and penetrate for some distance near their ends, what is considered, and probably is, an extension downward of the same sulphide mass. This would indicate an ore body at least 200 feet in length, following the dip of the vein, with both ends still unknown, and a known width at one point of 100 feet. Open-cuts in the croppings of the vein above No. 1 tunnel, all showing bands of ore from 2 to 4 feet in thickness, indicate an extension of the ore body, or at least of similar ores, upwards along the dip of the vein for a further minimum distance of 250 feet. The extension downward below No. 3 tunnel can only be ascertained by further development work.

In No. 2 tunnel a second important sulphide mass, 60 feet in length and over 8 feet thick in the central portion, was encountered. It is separated in the tunnel level from what may be considered the main ore body by a sparingly mineralized stretch of 30 feet, but may be connected with it above. It is exposed in the upper part of the upraise from No. 3 tunnel, but soon leaves it, as its dip is less than the slope of the raise. The two ore bodies found in cross-cuts from No. 3 tunnel, referred to above, may represent its downward extension, but the connexion has not been traced.

It is still an open question whether the various bodies of ore exposed in the workings form a continuous irregular mass with low grade patches, or consist of a number of separate ore bodies in close proximity. While many thousands of tons of ore are unquestionably present, any even approximate measurement of the amount is impossible until development work is more advanced.

Values.—The mine has been well sampled by the management and the values are fairly well known. They are in gold, silver, and lead, and usually aggregate from $11 to $12 per ton. The gold usually varies from 0·12 to 0·30 ounces, the silver from 5 to 25 ounces, and the lead from 3 per cent to 12 per cent per ton.

The following results of the sampling, selected from a large number of assays, are fairly typical of the general run of the ore:—

	Gold.	Silver.	Lead.
	oz.	ozs.	per cent.
Face of No. 2 tunnel, Sept. 4, width 5 feet	0·16	6·6	13
Slope in No. 2 tunnel, width 6 feet..	0·16	9·00	6
Face of No. 3 tunnel..	0·24	15·2	3·9
A sample of waste from No. 2 tunnel gave..	0·02	1·46	nil

The following assays by Mr. J. H. Marston, assayer for the Company, are inter-

esting as showing the tenor of the different sulphides in the precious metals. The material used was as pure as could be obtained:—

	Gold.	Silver.
	oz.	ozs.
Blende	0·10	5·20
"	0·10	3·00
Pyrite	0·30	13·50
"	0·30	20·00
Galena	0·10	85·00

Equipment.—Preparations are now almost completed for working the mine in an economical manner. An aerial tramway, used both to bring the ore down and supplies and other material up, has been constructed from No. 3 tunnel to the valley of Bear river, where a mill to concentrate the ore and separate the lead and iron sulphides has been erected. Glacier creek near by furnishes an excellent water-power, and this is used to operate the mill, and will also be used for the electric lighting and compressor plants in course of installation at the time of my visit.

The following description of the mine equipment was kindly furnished by Mr. W. J. Elmendorf, engineer and general manager.

Portland Canal Mining Company, Limited. Head Office, Duncan, B.C.

'The concentrating mill of the Company is located at Glacier creek, about 3½ miles north from Stewart. The mine is reached by a trail about 3 miles in length from that point, and is about 2,250 feet above tide-water.

'Water-power for the operation of the mill and air compressing plant is taken from Glacier creek by a flume 3 feet by 4 feet inside measurement and about 1,100 feet in length. Water rights to the amount of 2,000 miners inches are held by the Company.

'*Concentrating Mill.*—This is advantageously located on a hill-side millsite, and has a nominal capacity of 50 tons daily. The crushing machinery consists of a Sturtevant crusher, 2 pairs of Allis-Chalmers rolls and a slow speed Lane Chilean mill. The concentrating machinery includes four 4 compartment Abeling jigs, 1 each Wilfley and Overstrom tables, and 2 suspended type Allis-Chalmers 6 foot vanners. Settling tanks are provided for the slimes. The sizing is done by three trommels of the new sprocket driven type, and a very complete system of hydraulic classifiers. Especial attention is paid to the careful sizing of the ore.

'A short conveyer belt carries the ore from the crusher to the storage bin, which in turn feeds the first set of rolls by means of a revolving feeder.

'The ore is supplied to the mill by a covered chute, and this, with the two ore bins in the mill, furnishes a storage capacity of about 400 tons.

'Power is supplied by a 6 foot and 3 foot Pelton wheel working under a head of 100 feet. The larger wheel can be used to drive all the mill machinery, but the smaller can be connected with the jigs and tables in order to ensure constant speed for these machines. Its principal use is to drive the generator for the electric lighting of all the buildings.

'The conveying, crushing, and screening machines are ample for a mill of double the present capacity, and were installed with the contingency of an increase in the concentrating machines in view. Just what these will be, and in what number, will be determined by the behaviour of the present installation.

'Large bins for the concentrates are provided, and these fill from pipes and launders, thus avoiding the handling of any of the mill products, the middlings and tailings also being distributed automatically.

'The aerial tramway which connects the mine with the mill is of the Bleichert type, and was made by the Trenton Iron Works. It is 1⅜ miles in length, and of a 17 per cent grade. About 900 pounds of ore can be loaded into each bucket, of which

there are 26. A round trip is made in a little less than an hour, and the power for operation is furnished by gravity alone, the loaded buckets on one side bringing the empties and whatever mine supplies may be needed up on the other.

'The air compressor is a D-2 type Canadian Rand compound machine of 520 cubic feet free air per minute capacity. This is installed at the mill, and is direct driven by a 6 foot Pelton wheel. The air is conveyed to the mine by a 4 inch pipe line.

'An office, assay-office, and boarding house have recently been completed at a cost of about $7,000. These buildings are commodious and comfortable, a bath and many other conveniences being included in the men's quarters.

'The Company has expended more than $150,000 in development and improvements in the past two years.'

Jumbo, Ben Bolt, Etc.

The fissured, silicified zone on which the Portland Canal mine is situated extends up Glacier creek, and a number of claims, including the Jumbo, Ben Bolt, Chicago Nos. 1 and 2, and others have been located on it. These claims are now under bond to the Pacific Coast Exploration Company, and preparations are being made to explore them. A trail to the Jumbo was built during the past season, a bunk house and other buildings erected, and the Company late in the season was in a position to begin mining.

The vein on the Jumbo and Ben Bolt, the two claims at the southern end of the group, is exposed in a series of quartz cliffs, continuously traceable for a distance of 2,000 feet. The vein here is very strong, portions of it having an estimated thickness of fully 75 feet. It consists, as usual, of quartz holding fragments of slate, brecciated slates cemented by quartz, and silicified slates. Partially altered greenstone dykes, evidently apophyses from an intrusive mass which outcrops a short distance to the east, also occur in it in places.

The workings consist of some open-cuts along the base of the line of quartz cliffs.

The mineralization is irregular, and in most of the vein consists only of disseminated grains of pyrite. In a few places masses of pyrite, holding some galena and zinc blende, several feet in thickness, are exposed. The extent of these is now being investigated.

On Chicago No. 1 and No. 2 the vein, where exposed, has a thickness of from 20 to 25 feet, and is fairly well mineralized with pyrite, intermingled with a little galena. It looks promising in places, and deserves attention. The workings consist only of a short tunnel, and a couple of open-cuts.

Gipsy.

This claim is in the group owned by the Portland Canal Mining Company. It contains a vein about 3 feet in width, which is supposed to be a branch from the main zone of mineralization, but has not been actually traced into it. Its direction is nearly east and west, and the dip is southerly at an angle of 60°.

The Gipsy lead, while narrow, is traced for several hundred feet, and carries good values in places at least. The ore, mostly pyrite, galena, and blende in a quartz matrix, taken from a shaft sunk on the vein, assayed over an ounce in gold and 10 ounces in silver.

CLAIMS NORTH OF GLACIER CREEK.

O. K. Fraction.

The O. K. Fraction is situated on the western end of a fissured zone traversing the Bitter Creek argillites, traceable from Glacier creek eastward through a number of claims, and generally considered to be an extension of the Portland Canal lead. On the O. K. ground two quartz veins 60 feet apart are present, and quartz stringers

occur in the country between. The main vein strikes 10° east of north, and dips to the west at angles of from 45° to 70°. In places it is a well-defined quartz vein from 2 feet to 6 feet in width, while in others the quartz is intermixed with considerable slate.

The workings, which consist of a tunnel driven along or near the lead for a distance of over 150 feet, show no commercial ore. Native silver occurs in the croppings of the vein at several points.

Little Wonder.

This claim adjoins the O. K. Fraction on the east, and is being explored by the Portland Wonder Mining Company. The fissured zone from the O. K. passes into and crosses it. The workings consist of a shaft, a cross-cut tunnel 150 feet in length to the lead, and a drift of 150 feet along it. Some sulphide ore carrying good values occurs in the shaft, and bunches were also encountered in the drift. The management intend extending the drift 300 feet farther in order to undercut a portion of the vein said to carry good gold values in the surface showing.

Stewart Mining and Development Company.

This Company owns a group of claims stretched along a continuation of the same fissured zone outcropping on the O. K. and Little Wonder. A large amount of exploratory work has been done on the George E., one of the claims in the group, and several of the others have been prospected by surface cuts.

The argillites in the vicinity of the lead are much disturbed and dip steeply to the west. They are traversed by a number of dykes belonging both to the felsitic pre-mineralization and the basic post-mineralization series. In crossing the felsitic dykes the leads become restricted, and at times are represented only by stringers of quartz.

The fissured and crushed zone on the George E. has a width of over 350 feet, and includes four well-defined and nearly parallel quartz leads, one on the western and the other three on the eastern side of a deep narrow cañon which crosses the claim. The workings are situated in the bottom of the cañon, and consist of a cross-cut tunnel to the east, which cuts the three leads on the eastern side of the cañon known as Nos. 1, 2, and 3 veins, at distances of 50 feet, 140 feet, and 300 feet, and drifts along the leads of 60 feet, 120 feet, and 200 feet respectively. No. 4 vein on the western side of the cañon outcrops in the valley, and has been drifted along for some distance.

The veins have a general direction of N 12° E, and dip to the west at angles varying from 40° on the western or No. 4 vein to 80° in the eastern or No. 3 vein. Nos. 1 and 2 veins have dips of 55° and 45° respectively.

The eastern or No. 3 vein is the largest of the group, having a width in the tunnel of 27 feet. On the surface 200 feet above, its width is reduced to 7 feet. It consists of quartz, sometimes nearly pure but usually holding fragments of or alternating with the broken country rock. Some calcite is also present. No. 1 vein has a width of about 4 feet, No. 2 of 6 feet, and No. 4 of 8 feet.

The portions of the vein explored are all lightly mineralized, mostly with iron pyrite in grains and bunches, occasionally a little galena, some blende, and native silver. Specimens often yield high assays in silver and gold, but in general samples the values are low, seldom much exceeding $4 per ton. The veins look inviting and fully warrant the expenditure incurred, even if the persevering efforts of the management have not yet been attended with success.

The Main Reef.

The Main Reef claim is situated some distance north of the Stewart group, near the junction of the argillites with the Bear River greenstones. The vein explored is

narrow, in places practically a single, well-defined line of fissuring, bordered by crushed slates. It overlies a large, westerly dipping granitic dyke, which forms the foot-wall of the vein in portions of its course, and in others is separated from it by a few feet of argillite.

The vein or fissure has a general direction of N 10° E, but curves slightly along its course, and it has a westerly dip of from 30° to 50°. It has been explored by a drift for a distance of 240 feet. Near the mouth a small ore shoot up to 30 inches in width and about 40 feet in length was encountered, and light mineralization continues to the face. Near the end of the drift small bunches of galena in a calcite gangue occur in the fractured slates.

The ore consists of pyrite, galena, and blende in a calcite gangue. Four tons of picked ore, shipped, yielded:—

Gold, 0·7 ounce; silver, 20·94 ounces; lead, 23 per cent.

Several other showings on the claims have been prospected, one situated at the base of the same large felsitic dyke which underlies the main lead. This consists of 4 to 5 feet of silicified slates, mineralized with pyrite, blende, and some galena and chalcopyrite.

Tyee.

The Tyee is situated on the Main Reef trail from Bear river at an elevation of 300 feet above the valley. The argillites here are cut by a granitic stock, and the showing occurs in fractured granite. The development work consists of a shaft, filled with water at the time of my visit, and an open-cut 40 feet to the north. Three feet of shattered and partially silicified granite, holding considerable pyrite and occasional bunches of chalcopyrite, are exposed in the cut.

Silver Bow Group.

These claims are situated on the upper waters of Maude gulch, a tributary of Glacier creek. The argillites here are interbanded with altered greenstones, which are probably intrusive into them. The principal showing seen occurs in Maude gulch, at an elevation of 2,850 feet, and follows one of the greenstone bands. The lead is a strong one, the massive greenstone being fractured and irregularly silicified and mineralized for a width of 10 to 15 feet in places. Pyrite in small lenses, bands, and scattered grains is the principal mineral present. Associated with it are small quantities of blende, galena, and tetrahedrite. The lead is traceable along the creek for fully 700 feet. The workings consist of a couple of shafts, and some open-cuts.

Some work was done on this lead during the past season by the Silver Bow Mining Company under bond, but the values obtained did not come up to expectations, and the bond is reported to have been thrown up.

A galena showing on the west branch of Maude gulch was also investigated by the same Company. It occurs in argillites, and consists of a narrow vein of galena and blende, about 6 inches thick, where widest. It proved to have little permanence.

Northern Belle.

This claim is situated west of the glacier from which the North fork of Glacier creek issues, at an elevation of 3·175 feet. Only a little stripping has been done. This exposes an oxidized lead 5 to 6 feet in width, made up of quartz and slate, and mineralized with pyrite and smaller quantities of chalcopyrite. The latter often occurs in small solid masses several inches across. The lead has an east-west strike, and dips to the south at an angle of 40°. It is exposed for a distance of 50 feet.

CLAIMS IN BASIC INTRUSIVE AREA AT THE HEAD OF GLACIER CREEK.

Columbia and Evening Sun.

These two claims, one south and the other north of the Middle fork of Glacier creek, are being explored by the Lordigordy Mining Company. A vein, usually narrow, but sometimes 6 feet to 8 feet in width, striking about N 30° E, occurs in both claims, and is supposed to be continuous, but is concealed where it crosses the creek, and for some distance on either side. The vein is usually rather sparingly mineralized, but contains occasional narrow shoots, up to 8 inches in width, of rich ore made up of fine and coarse-grained galena, running high in silver, tetrahedrite, blende, and pyrite. Two of these shoots, one on the Columbia at an elevation of 450 feet above the creek, and the other on the Evening Sun at an elevation of 600 feet, are now being investigated. The vein filling consists mostly of siderite and calcspar, usually intermixed with more or less of the crushed and schistose country rock. Small shipments of high grade ore have been made from the claims.

Silver King.

This claim, owned by Andrew Nelson, adjoins the Evening Sun on the northeast, and the vein on the latter has been traced into it for a distance of 300 feet. The vein has been drifted at several points. It is irregularly mineralized, most of it sparingly, but a couple of small shoots of ore are exposed in the workings. The minerals present include galena, blende, stibnite, tetrahedrite, and pyrite. The principal gangue mineral is siderite.

Katherine Claims.

This claim is situated near the glacier at the head of the North fork of Glacier creek, at an elevation of 3,400 feet. It is one of a group owned by the Rush Portland Mining Company. A vein from 1 to 3 feet in width occurs on the claim, and has been followed by a drift 87 feet in length at the time of my visit. Open-cuts exposed the vein for a further distance of over 100 feet in a southeasterly direction, and it is also traceable from the portal of the drift northwesterly for some distance. The gangue is siliceous, and the metallic minerals present include ordinary and arsenical pyrites, galena, blende, and tetrahedrite. The principal values are in silver.

Ajax.

This claim, situated on the east side of the South fork of Glacier creek, about 700 feet above the valley bottom, is being examined by the Pacific Coast Exploration Company. An oxidized zone, striking nearly east and west, and dipping to the north, about 25 feet wide, occurs on the claim. A portion of the zone, near the hanging wall, from 5 to 6 feet in width, is well mineralized with pyrite, zinc blende, and some galena. The showing is being explored by a drift, only in 30 feet at the time of my visit.

Excelsior.

This claim was visited by Mr. Malloch, who furnishes the following description:—

The Excelsior claim is situated on the spur between the Middle and the South forks of Glacier creek, and the main showings occur within a few hundred feet of the ice field which feeds the glacier descending to the head of the South fork. Two veins occur about 100 feet apart and striking approximately north and south. The eastern vein is about 2 feet in width and is well mineralized with galena, zinc blende, and subordinate amounts of grey copper in a gangue of siderite. Specimens from the

capping are reported to have assayed 300 ounces of silver to the ton. This vein dips at about 65° to the west. The second vein strikes more to the northeast and southwest than the first and the dip is nearly vertical. The maximum width observed was 18 inches. The same minerals are present, but there is rather more zinc blende and less galena. Some shallow pits had been sunk on the veins, but comparatively thick deposits of morainic material would have to be removed before the continuation of the veins for any considerable distance in either direction could be demonstrated. Numerous quartz veins were seen on this claim, striking generally east and west, but except for a few copper stains no indications of economic minerals were observed.

CLAIMS ON BITTER CREEK.

Black Bear Group.

These claims are situated southwest of the Bromley glacier, the source of Bitter creek, 2¾ miles above the snout of the glacier, and 10 miles above the mouth of Bitter creek. They were the cause of considerable excitement for a while last season, owing to the spreading of exaggerated accounts in regard to the size and richness of the leads which cross them.

The rocks along the southwest side of the Bromley glacier consist mainly of the dark grey Bitter Creek argillites. They are less altered than on Glacier creek, are often striped and include occasional tufaceous bands. They strike nearly north and south, and dip regularly to the west at angles of from 38° to 40°.

A prominent feature of the geology is the number of large greyish felsitic dykes which alternate with the dark argillites. They run nearly horizontally along the bare steep mountain slopes and look like a succession of sills. They conform, as a rule, very closely to the dip and strike of the argillites, but occasionally cut across them at a considerable angle. The series of brownish weathering, dark, basic, post-metalliferous dykes are also well represented.

The leads consist of crushed and silicified zones of various sizes up to 15 or 20 feet in width, which, like the dykes, follow closely the dip and strike of the argillites. The principal croppings occur on Gold Bluff No. 2 claim, at a height of 600 feet above the glacier, and about 3,700 feet above the sea. The lead at the point examined consists of about 15 feet of quartz and silicified argillites, holding considerable iron pyrite in places. A red zone, usually inaccessible and in places concealed by wide slides, outcrops at intervals along the mountain side, at about the same height, for a distance of half a mile or more, and probably represents the extension of the lead. A number of smaller showings occur at various other points in the vicinity, some of which are sparingly mineralized with chalcopyrite and galena in addition to the pyrite.

The pyrite in the main lead where examined is gold bearing, but the values are too low to constitute it a commercial ore under present circumstances. It is, however, only accessible at one or two points, and it is possible that in other portions of its course better values may be present. No exploratory work has been done on it. Good looking float occurs in some abundance along the foot of the slopes, but the source of this has so far not been determined.

Old Chum Group.

These claims are situated about a mile up Hartley gulch, a steep mountain torrent which joins Bitter creek from the east, three-fourths of a mile above the termination of the Bromley glacier. The principal showings occur on Old Chum No. 2 claim, and consist of three fissured and mineralized zones in a space of 130 feet, traversing slates in a direction a few degrees south of east. The centre lead is about 4 feet wide, and is made up of quartz and decomposed and reddened slates. The

slates bordering it are broken and pyritized for some distance. It contains galena in grains and bunches, and iron pyrite. The pure galena carries 80 ounces in silver and $2 in gold per ton. The south lead is seamed with quartz stringers for a width of 15 feet, and mineralized with iron and a little chalcopyrite and blende. The north lead is about 6 feet wide, and minaralized chiefly with pyrite. The workings consist only of some surface cuts insufficient to indicate the extent or importance of the deposits.

L. L. and H. Group.

The claims in this group are situated on the side of Hartley gulch a short distance below the Old Chum group. The argillites here are intruded by greenstones, and are contorted and broken in places. The principal showings occur on the Union Jack and Famous claims, and consist of three nearly parallel lines of fissuring, one of which, the centre one, is traceable along the precipitous slopes which border the valley for a distance of about 1,000 feet. The width of the fissured and partially silicified and altered zone varies from a few inches to 6 feet. The mineralization is irregular, and consists mostly of iron with some arsenical pyrites. Small quantities of galena and chalcopyrite are also present in places. The pyrite carries significant gold and small silver values. A coarse-grained variety yielded $8 in gold and $1.38 in silver per ton, and better returns have been obtained from selected samples.

The upper lead has a width of over 10 feet and carries considerable galena. It has not been traced out.

The claims have only been staked recently, and with the exception of a short cross-cut tunnel into the foot-wall of the upper lead no work has been done on them.

Roosevelt.

The Roosevelt is situated on the North fork of Bitter creek near the bottom of the valley, about a mile above its junction with the main stream. The Bitter Creek argillites, which form the country rock in the vicinity, are cut and disturbed by numerous dykes referable to three periods. The oldest set is much altered, and consists of greenstones, probably of the same age as the intrusive area at the head of Glacier creek. These are cut by large greyish felsitic or granitic dykes, and later by brownish-weathering basic dykes.

The main lead occurs below one of the greenstones dyke and has been followed by a drift for a distance of 70 feet. It consists of 5 feet of broken and silicified country rock, carrying some pyrite and chalcopyrite. The mineralization diminishes towards the end of the drift. A small lens of good chalcopyrite ore has also been uncovered above the dyke. A good trail to the claim was built during the summer, and a bunk house erected, but little mining work was attempted.

Bitter Creek Mining Company.

This Company owns a group of thirteen claims situated along a small stream which enters Bitter creek from the north, immediately below the North fork. Some work has been done on the Cupron and Swede-American No. 14. The latter is situated above the timber line, at an elevation of about 4,000 feet above the sea. A lead about 12 feet wide, which occurs on it, has been drifted for a distance of 45 feet. It consists of crushed and broken argillites, often partially decomposed, seamed with numerous irregular veins of quartz and calcite. The metallic minerals present are galena, blende, and iron pyrite. The pyrite is stated to carry good silver values. The lead is a strong one and seems worth following up, although no continuous body of commercial ore is exposed in the present workings.

The Cupron showing is situated lower down the creek at an elevation of 1,650 feet above sea-level. It outcrops in the creek bottom, and is exposed for a distance of 60 feet. The lead has a thickness of about 5 feet, and consists of a broken slate gangue, with bunches and stringers of quartz and calcite, well mineralized in places with chalcopyrite, galena, and pyrite. A cross-cut tunnel to intercept the lead in depth has been started but not completed.

Gold Bar No. 1.

This claim is situated south of Bitter creek about a mile above its mouth, and at an elevation of 1,000 feet above it. It contains a quartz vein, which follows the ragged contact between a granite area and the Bear River greenstones which it intrudes. The quartz vein has a width of from 4 to 10 feet, and is stripped at intervals for a distance of 150 feet. It contains some disseminated iron pyrites, and weathers to a yellowish colour. It is stated to carry fair gold values, but no assays were seen.

A second quartz vein, or a continuation of the first, outcrops on the Blue Belle No. 1 claim 400 feet to the south.

CLAIMS IN RIDGE WEST OF BEAR RIVER AND AMERICAN CREEK.

International Portland Mining Company.

This Company owns a group of eight claims situated on the ridge west of Bear river, opposite the mouth of Bitter creek. Three of the claims, the Mammoth, Dundee, and Ben Lomond, were prospected during the summer.

The Mammoth showing, as exposed in an open-cut 500 feet above Bear river, consists of a fissured zone about 18 feet wide, cutting an argillaceous band enclosed in the Bear River greenstones. At the south wall of the zone the slates are crushed and decomposed for a width of 3 feet, and mineralized somewhat sparingly with pyrite, galena, and blende. Good values are reported from this portion of the lead near the surface. A tunnel 50 feet lower down the slope follows the same crushed zone for a distance of 40 feet. The same minerals are present, but in smaller quantities.

The Dundee showing is situated some distance north of the Mammoth, at an elevation of 850 feet above Bear river. It occurs in the same argillaceous band as the Mammoth, and consists of the broken country rock, seamed for a width of about 10 feet with small irregular quartz veins. Pyrrhotite, pyrite, blende, and a little galena are present.

The Ben Lomond is situated much higher up the mountain slope, at an elevation of about 2,300 feet above Bear river. The country rock here is the Bear River greenstones, altered in places into a light coloured schist. Irregular areas of the greenstones are heavily charged with pyrite, and bright red and yellow patches due to its oxidation are traceable along the mountain side for over half a mile. Some quartz in bunches and veins occurs in the mineralized areas, and chalcopyrite has also been found in several places, but so far not in commercial quantities. Exploratory work was commenced late in the season, and consists only of surface cuts.

Red Cliff Mining Company.

This Company owns a group of six claims and some fractions, situated along Lydden creek. This stream cuts a deep gash in the Bear River ridge west of the forks of American and Bear creeks, then bending southward, flows for some distance before joining Bear river, parallel with it and in the same valley. The mountain ridge west of the valley rises in steep cliffy slopes at an angle of fully 55°, and on the bare sides the red oxidized zones and patches which first attracted the attention of the prospectors are clearly outlined.

The country rock in the vicinity consists altogether of the Bear River greenstones, here a dark green, even-grained, massive appearing rock, without recognizable phenocrysts. It is considerably altered, and in the lower tunnel lines of schistosity have developed in places. It is cut by granitic dykes, and by later brownish-weathering basic dykes, neither of which have any evident connexion with the mineralization.

The Red Cliff claim, on which nearly all the development work has been done, is situated near the southern end of the tier of claims, and while west of Lydden creek is practically in the Bear River valley and easily accessible. The principal croppings occur near the base of the mountain, commencing 60 feet above Lydden creek and about 900 feet above sea-level, and consist of lenses of sulphide ore slightly oxidized on the surface and clearly traceable up the mountain slope for a distance of about 400 feet. The surface outcrops show two main lenses striking in a southwesterly direction, and separated by a barren stretch 100 feet in length measured along the slope. The lower lens has a width of from 5 to 25 feet, and the upper of 3 to 8 feet.

A tunnel has been driven into the lower lens, proving the ore body for a distance of about 70 feet. The full length is not known, as the tunnel bends to the right and leaves it. At the portal the ore body has a width of 5 feet, and 50 feet in, a minimum width of 15 feet, with the left wall still concealed. The drift cuts the lens 120 feet below the highest part exposed on the surface.

The upper lens has not been worked. It is narrower than the lower one, and contains a smaller proportion of chalcopyrite. Other smaller lenses occur in the vicinity.

The lenses or ore bodies are irregular in outline, and are only occasionally bounded by definite fissured walls. While probably deposited along zones of weakness, this is not evident either on the surface or in the workings. Fissures occur in their vicinity, some crossing and apparently younger than the ore body, but are not more numerous or better marked than in places showing little mineralization.

The gangue matter is mostly the altered country rock, usually silicified to some extent, and seamed in places with small irregular quartz veins. Some calcite is also present. The metallic minerals are chiefly pyrite and chalcopyrite, with a little zinc blende. The chalcopyrite occurs in grains, small solid bunches, and in narrow bands alternating with the pyrite; and both the pyrite and chalcopyrite contain varying gold, and small silver values.

About 200 tons of ore have been taken from the workings. The copper tenor of this is estimated at from 4 per cent to 5 per cent, and the total values in copper, gold, and silver at about $20 per ton.

During the past season the principal work in the Red Cliff mine consisted in driving a long tunnel designed to undercut the ore body at a depth of 280 feet below the upper workings. The tunnel passes below Lydden creek at a depth of 60 feet, and when completed will have a length of about 1,300 feet. Reports received since leaving the camp state that ore has been reached at about the estimated distance.

The mine is equipped with a 10 drill air compressor, two 60 horse-power boilers, and an electric lighting plant. A power plant on Lydden creek is projected.

A number of other showings, some seemingly important although little or no work has so far been done in them, occur in the tier of claims owned by the Red Cliff Mining Company. Ascending Lydden creek a large patch, reddened irregularly and fully 100 feet across, occurs at the top of a steep talus slope near the junction of the Red Cliff and Little Pat claims. The mineralization is more scattered than in the Red Cliff showing, and consists mostly of pyrite, with some chalcopyrite in spots. The average values are not known. Farther up Lydden Creek cañon an outcrop of ore on the Montrose claim has excited considerable interest on account of the high gold values it contains. The exposure, as seen in the cliff rising up from the valley bottom, has a length of 35 feet, and a minimum width of 15 feet, and consists of the

country rock more or less completely replaced with quartz and pyrite. Some galena and copper carbonates occur along the inner wall. Assays of over $100 per ton in gold have been obtained from the pyrite in this ore body. Other wide croppings occur farther up the valley in the same line, and also on the opposite side of the cañon a short distance lower down.

Ouray and Big Casino.

Exploratory work on these claims was commenced last season by the Big Casino Mining Company. They are situated on the same mountain as the Red Cliff, but farther up Lydden creek and at a much greater elevation, the altitude at the Big Casino workings, as registered by the aneroid, being 3,140 feet above sea-level. A zigzag pack trail up the steep mountain to the showings was completed during the summer.

The Ouray showing occurs in a fissured zone, about 15 feet wide where best seen, traversing the Bear River greenstones in a southeasterly direction, and dipping to the northeast. The lead has been stripped for a distance of 200 feet. It consists of the fissured country rock, sparingly silicified and mineralized with galena, pyrite, and some chalcopyrite in scattered grains and bunches.

The Big Casino showing has a width of 35 feet, and has been stripped for 60 feet. It contains considerable quartz, and is mineralized with pyrite, chalcopyrite, and bunches of galena. A drift along the lead had just been started at the time of my visit.

Initial Group.

This is situated south of Big Casino group on the same mountain, but towards the Goose Creek slope, at an elevation of 3,135 feet. A band of granitic rocks and quartz porphyries runs northwesterly from Bitter creek up Goose creek and across to the Salmon river, and the main showing occurs near the northern junction of this with the Bear River greenstones. The showing consists of two mineralized zones, one 6 to 12 feet in width, and the other up to 25 feet in width, separated by a felsitic dyke. The leads strike N 30° W, dip towards the granitic belt, and are irregularly mineralized with pyrite, chalcopyrite, and galena. Very little work has been done on them.

Red Cliff Extension.

The Red Cliff extension is situated high up on the slopes of the mountain north of Lydden creek, at an altitude of 3,500 feet above the sea. The rocks here, as at the Red Cliff, are the Bear River greenstones. Higher up on the mountain they are overlaid by the tuffs and agglomerates of the Nass formation. The greenstones are traversed by a zone of fissuring running nearly east and west. This has been opened up by two surface cuts about 100 feet apart, and 100 feet lower down the slope an exploratory drift along the lead has been started. The lower cut exposes a small lens of good chalcopyrite ore. At the upper cut the fissured country rock is largely replaced, for a width of 12 feet, with quartz, often red and jaspery, and calcite, and carries some pyrites, and small quantities of galena and chalcopyrite.

Mountain Boy.

This claim is one of the oldest in the district, having been staked in 1902. It forms one of a group now under bond to the Pacific Coast Exploration Company, and is situated in the lower slopes of the mountain ridge, bordering American creek in

the west, about 4 miles above its junction with Bear river. The rocks here, while referred to the Bear River formation, are more porphyritic than usual, and are often reddened irregularly. They are slightly schistose in places.

The showing occurs at the top of a steep talus slope, at a height of about 1,000 feet above the valley bottom and 2,200 above the sea, and is a somewhat imposing one, as the fissured and broken country rock for a width of about 25 feet is almost completely replaced by a mass of quartz, calcite, and barite, which projects along the surface in a pinnacled cliff. The lead strikes nearly east and west, and dips to the south at an angle of 50°. Traced up the steep hill it soon becomes less well defined, and the proportions of secondary minerals present gradually diminish. The extension of the lead downwards towards the valley is buried beneath slide material.

The Pacific Coast Exploration Company was occupied most of the season in the necessary preliminary work of trail building, erecting winter quarters, etc., and had not commenced actual mining at the time of my examination. The old workings consist of a tunnel about 100 feet long, which starts on the lead, but soon leaves it and then bends gradually round to the left in an effort to pick it up again. It affords little information.

The metallic minerals present consist mostly of zinc blende, galena, pyrite, and chalcopyrite distributed somewhat sparingly in grains, veinlets, and small bunches through a mixed gangue of quartz, calcite, and partially altered country rock. The deposit, as a whole, is low grade so far as explored, although fair assays, mostly in silver, are reported from portions of it. Some good ore occurs along a cross fissure which cuts the lead 75 feet above the portal of the tunnel.

Several parallel zones of mineralization, all somewhat similar to the one just described, occur in the vicinity.

CLAIMS IN MOUNTAINS BETWEEN BEAR RIVER AND AMERICAN CREEK.

Bonanza.

The Bonanza claim is situated between Bear and American creeks, about a mile above the junction, and at an elevation of 400 feet above it. The showing occurs in a band of slates enclosed in the Bear River greenstones, and consists of a narrow vein made up of brecciated slate and quartz, holding a small seam of nearly solid galena from 2 to 5 inches in thickness. The galena seam is exposed on the surface, and in a pit sunk on it for a distance of 40 feet. An open-cut, 75 feet farther north-northwest along its strike, shows the lead, but it is here less well mineralized.

The galena occurs in a coarse, cubical condition and is associated with a little chalcopyrite, blende, and pyrite. The pure galena is stated to give values of $90 in lead and silver.

Catchem.

The Catchem claim is situated east of American creek, about 2½ miles above its forks with Bear river, and the showing on it is very similar to that on the Bonanza. The country rocks consist of a band of argillites and tuffs in the Bear River greenstones. Some of the beds contain considerable lime in small lenses following the bedding planes. These weather readily, and on exposed surfaces the rock has a honeycombed appearance.

The lead or fractured zone has a width of 5 or 6 feet, and contains on the hanging wall a seam of nearly pure, mostly fine-grained galena up to 6 or 8 inches in thickness. This is followed by 2 feet of broken country rock, carrying some galena in small stringers and bunches. The workings are insufficient to define the extent of the deposit either in strike or depth. A long tunnel to undercut the lead at some depth has

been started but not completed. Assays of the ore show from 45 ounces to 107 ounces in silver per ton, while one exceptional specimen is said to have run several hundred ounces.

Ruby No. 2.

This claim was not seen by the writer, but was examined by Mr. Hayes. It is situated on the Bear River slope of the ridge between Bear river and American creek, at an elevation of about 2,700 feet above the sea. The rocks in the vicinity consist mostly of the greenstone agglomerates of the Bear River formation with some included slaty bands. A quartz vein from 7 inches to 2 feet in width, and traced by surface stripping for 250 feet, occurs on the claim. The quartz contains considerable iron pyrite, and in places assays high in gold, returns of several ounces per ton having been obtained from selected specimens. The vein is now being investigated by the Portland Bear River Mining Company.

CLAIMS ON BEAR RIVER ABOVE AMERICAN CREEK.

Independence.

This claim is situated in the Bear River cañon, a constricted portion of Bear River valley, a mile and a half above the American Creek forks, and was explored during the past season under bond by the Bear River Cañon Mining Company. The showing occurs in a band of slates, tuffs, and limestones enclosed in the Bear River greenstones. These are traversed in a nearly north and south direction by a well marked line of fissuring which follows closely the strike of the rocks. The fissure has been drifted on for a distance of 140 feet. A lens of nearly solid galena, with some blende about 8 inches in thickness which outcropped on the surface, was cut through in a distance of 20 feet. A second lens, consisting mostly of blende with some galena, was encountered at 50 feet and followed for 12 feet, and beyond that the fissure proved barren. A shaft at the mouth of the tunnel followed the galena lens down to a depth of 15 feet when it disappeared.

Similar narrow lenses of galena ore, on what seems to be the same line of fissuring, occur north of Bear river on the Victor claim, but have not been investigated.

Bear River Mining Company.

This Company was engaged during the season in prospecting a group of claims situated south of Bear river, some distance above the Bear River cañon. The country rocks consist mostly of fragmental greenstones often silicified over large areas, and are referred to the Bear River formation. Reddish oxidized zones and patches, some of considerable extent, are numerous in the vicinity. One of these on the New York claim was opened up by a short drift. It consisted mostly of pyrrhotite distributed irregularly through the country rock, and associated in places with a little chalcopyrite. The mineralized mass has a width of over 30 feet. Its length was not determined. A second mineralized mass fully 30 feet wide occurs in the London claim; iron pyrite is the principal mineral present. The gangue, mostly the altered country rock, contains garnets in disseminated crystals.

Float chalcopyrite ore occurs in some quantity in the wash of a glacial stream which descends from the mountains, a short distance east of the London claim. The region at the head of the stream is exceedingly precipitous and difficult to explore, and the source of the ore has not been definitely determined.

THE SALMON RIVER DISTRICT.

Before leaving the Portland Canal district, a couple of days were spent on the Salmon river, where promising discoveries of ore were reported, in company with Mr. H. B. Williams, M.E., manager of the Salmon Glacier Mining Company, one of the companies operating there.

Transportation into this district at present is by no means easy. A rough boggy horse trail has been cut up the valley for a distance of 8 or 9 miles, from which point supplies and other materials needed are packed on men's backs to the foot of the Salmon River glacier, a distance of about 4 miles, along the glacier for several miles, then up the steep mountain side to the various camps.

Salmon river parallels Bear river on the north, the two streams being separated by a long mountain ridge, and empties into Portland canal near its head. It is a swift, branching stream, usually from 75 to 100 feet in width where confined, and a length to the glacier at its head, measured along the valley, of about 12 miles. Its grade averages 40 feet to the mile. An important tributary heading in or passing through several large lakes joins it from the east 9 miles above its mouth.

The glacier at the head of Salmon river is a large one, its width averaging over a mile. Salmon river heads with a branch of the Nass, and the glacier extends across the summit and flows for some distance down a tributary of the latter, its total length probably exceeding 12 miles. Its principal feeder is a large ice stream, which joins it almost at right angles, from the west, at the summit.

The Salmon River valley, like Bear River valley, is, in the lower 10 miles of its course, a wide, straight, flat bottomed glacial trough, partially filled with alluvial gravels, sands, and silts. Above the forks a long spur projects into the valley from the west, beyond which the flats resume and continue to the moraines at the foot of the glacier.

Rocks.—The rocks exposed along the Salmon River valley up to the foot of the glacier consist mainly of the granites and granodiorites of the Coast Range batholith. These are replaced east of a line running diagonally across the valley near the foot of the glacier by greyish green rocks, sometimes massive but usually in a more or less schistose condition, the lines of schistosity striking nearly north and south and dipping to the west. They resemble the more schistose varieties of the Bear River formation, and may represent an altered phase of that formation. A narrow band of crystalline limestone is included at one point.

A wide band of dark, almost black argillites crosses the valley of the East fork about 3 miles above its mouth. The argillites are younger looking than the greenstone schists, and apparently overlie them, but the relationship was not clear in the exposures seen.

Granitic dykes and stocks are numerous along the valley east of the main batholith, and a series of later post-metalliferous basic dykes similar to those in the Bear River valley are also well represented.

Mineralization.—The showings seen occur altogether in the greenstone schists, and consist mainly of reddish coloured oxidized zones and areas, some well-defined and with a regular trend, and others very hazy in outline. A series of these oxidized patches some 100 feet or more across, was followed along the valley, east of the glacier and at an elevation of about 1,000 feet above it, for a distance of over 2 miles, and they are reported to extend up the valley for several miles farther. Well marked lines of fissuring occasionally traverse, or partially or wholly bound the mineralized areas, and, in a few instances, they have the regularity of veins, but in most cases the boundaries are marked only by a sudden or gradual cessation of the mineralization.

The oxidation is shallow, the unaltered sulphides usually being found immediately beneath the surface.

The metallic minerals in the showings consist largely of pyrite, associated in places with galena, chalcopyrite, and blende. The principal values are in silver, gold, and lead, no large copper deposits having so far been found. The silver tenor of the galena is reported at about 50 ounces per ton, and $19 in gold per ton has been obtained from the pyrite.

The principal gangue is the altered country rock usually more or less silicified but seldom entirely replaced. Some calcite is also occasionally present.

Workings.—During the past season some exploratory work, mostly surface cuts, was done on a few claims by the Salmon River Glacier Mining Company and the Golden Crown Mining Company. The work, while too limited to afford conclusive results, has proved the existence of several ore concentrations certainly worth further exploration.

The Salmon River Glacier Mining Company hold four claims situated on a hummocky ridge bordering the Salmon River glacier on the east, at an elevation of about 1,300 feet above the glacier, and 3,400 above the sea. The showings consist of mineralized zones traversing the greenstone schists, which form the country rock in an approximately north and south direction. The zones are well mineralized and carry pay values in places, at least, but the persistence of these values along the strike and in depth still remains to be demonstrated.

Several of the zones were trenched across and sampled during the season by Mr. H. B. Williams, engineer and manager for the Company. A cut on the Martha Ellen claim sampled for 29 feet yielded, according to Mr. Williams, 0·34 ounces gold, 2·1 ounces silver, 3·6 per cent lead, and 0·2 per cent copper. A second cut in the same claim 49 feet in length, sampled for 10 feet, yielded 0·45 ounce gold, 13·8 ounces silver, 27·6 per cent lead, and 1·1 per cent copper. A cut on the Glacier claims yielded along a 10 foot stretch 0·26 ounces gold, 4·0 ounces silver, and 11·2 per cent lead. These values are about equal to those in the ores mined by the Portland Canal Mining Company.

Farther southeast along the mineralized belt are the claims, over 30 in number, held by the Golden Crown Mining Company. Some preliminary work has been done on the Rambler, Buena Vista, Province, Big Missouri, and a few others. A well-defined vein occurs on the Rambler, the filling consisting of quartz and the brecciated country rock mineralized with pyrite and some galena. On the Buena Vista a red oxidized hill top has been drifted for a distance of 36 feet. The minerals present consist of pyrite, with some galena and blende and occasional specks of chalcopyrite. A general sample along the tunnel is stated by the management to have yielded $16 per ton in gold, silver, and lead. The extent of the deposit is still unknown. At the Big Missouri, the cliffy hillside is reddened and irregularly mineralized, mostly with pyrite, for a width of several hundred feet. The face of the hill has been stripped for 100 feet and a tunnel driven in 35 feet. The tunnel passes through 8 feet of good looking ore, beyond which it penetrates oxidized and pyritized schists. The ore minerals are pyrite, chalcopyrite, galena, and blende. Veinlets and bunches of calcite, and some quartz occur in the gangue. A tunnel has been started lower down the slope to explore the deposit in depth.

The Portland No. 2 claim is situated farther down the glacier near the south-eastern end of the known mineralized belt and is being opened up by the Portland, Salmon River syndicate. A strong lead striking S 20° E, and dipping to the east at a high angle, occurs on the claim. The lead is bordered on the east by a felsitic dyke altered and sparingly mineralized near the contact, and on the west by green schists, and has a width on the surface at one point where cut across, of 14 feet. A section across the bottom of the cut shows 8 feet of nearly solid galena, followed by 6 feet of mineralized and silicified country rock passing near the dyke into nearly pure quartz. The galena, according to Mr. Williams' sampling, assays from 25 per cent to 45 per cent in lead, from 13 ounces to 16 ounces in silver, and from $1.20 to $2.10 in gold. A general sample from the silicified portion of the vein yielded $1.10 in gold, 6 ounces in silver, and 5½ per cent lead.

The galena is only exposed in the cut. It narrows above, and the workings are not sufficient to determine whether it occurs in a large bunch or short lens in the lead, or persists for some distance along it. The lead at a second cut 150 feet to the

south shows little galena, but contains fair gold and silver values, a general sample yielding 0·38 ounces in gold and 3·2 ounces in silver per ton. Preparations are now being made to drift along the lead from a point 300 feet south of the main galena showing. The country falls rapidly in that direction, and the drift at the showing will have a depth of 150 feet.

TOPOGRAPHIC WORK IN THE PORTLAND CANAL DISTRICT.

NORTHERN BRITISH COLUMBIA.

(G. S. Malloch.)

Topographic work in connexion with the geological survey of the Portland Canal district, by Mr. R. G. McConnell, was begun early in June, and continued until near the end of September. Signals erected by the Canada-Alaska Boundary Commission were used as a base for a system of triangulation extended so as to control a large part of the valleys of Bear river and its tributaries. Thirteen dozen photographs were secured from the triangulation points to record the main features of the topography, and compass and telemeter surveys were run of the wagon road, trails, and some of the streams in the thickly wooded portions of the valley where their positions could not be determined by means of the photographs. An endeavour was made to fix the positions of all mines, tunnels, and important prospects, but the latter were so scattered, and their number was so large that it was found another season's work would be necessary to secure data for an adequate mining map of the district. The area in Canadian territory at the head of the Salmon river, and the valley of Marmot river, remains to be done, as well as the upper parts of the valleys of Bear river and its two principal tributaries, American and Bitter creeks. A sketch map of the district has been prepared for publication in the Summary Report. It is based on the traverses without photographic control, but it is hoped that the distances between points will prove roughly correct. The prospects are indicated by crosses, and the salient topographic features by broken contours.

The writer's thanks are due to many mine foremen and prospectors who often went to a great deal of trouble to point out prospects on their properties, and evinced a desire to help the work in any way possible.

Mr. S. D. Robinson proved an efficient and painstaking assistant.

SKEENA RIVER DISTRICT.

(W. W. Leach.)

During the past season work was confined chiefly to the vicinity of the Bulkley valley; the greater part of the time being spent in connecting up the work of past seasons—both geological and topographical—with the idea of collecting sufficient information to complete a map now under compilation. This map will include the greater part of the Bulkley valley from Hazelton to a point about 20 miles north of Aldermere, as well as parts of the adjoining country.

Great activity has been evidenced in prospecting this district, and it is hoped that, on the completion of the Grand Trunk Pacific railway, which traverses the valley, many mines, both coal and metalliferous, will be opened up.

A few days were spent in the vicinity of Kitsalas, where a hurried examination was made of some of the mineral properties there.

Every facility for the examination of the various properties was extended to the writer by the respective managers and owners.

Field work was carried on from the end of May until the end of September. It consisted chiefly of more or less detailed examinations of the most important properties, and an attempt to correlate the geological features of the various isolated districts examined in previous years.

The main topographical work done was the connecting up of the transit triangulation of past seasons, and this again with the British Columbia land surveys and the railway survey. The triangulation was supplemented by panoramic sketches from all stations occupied. Pace and compass traverses were run on practically all the travelled trails in the district.

Material aid in the work was rendered by Mr. S. E. Slipper, who acted as assistant.

LOCATION AND AREA.

The Bulkley river is the most important tributary of the Skeena, entering that river from the southeast about 150 miles from its mouth. The town of Hazelton, the present commercial headquarters of the district, is situated at the junction of the two rivers, at the head of river navigation of the Skeena, which is carried on with considerable difficulty by a number of small stern-wheel steamboats. From Hazelton, a fair wagon road extends up the Bulkley valley to Aldermere (56 miles) and beyond, from which many trails branch off on either side. The area under examination includes the valley of the Bulkley for a distance of about 75 miles from its mouth, and extends back from the river for from 15 to 35 miles on both sides.

The village of Kitsalas is situated at the foot of the cañon of the same name, on the Skeena river about 60 miles below Hazelton.

PREVIOUS WORK.

Dr. Dawson in his report on 'An Exploration from Port Simpson to Edmonton' (Report of Progress 1879-80) briefly reviewed the geology of part of this district; while Mr. Wm. Fleet Robertson, Provincial Mineralogist for British Columbia, visited the mineral properties of the Telkwa in 1905 (Report of Minister of Mines for British Columbia, for 1905). Apart from these reports, nothing has been written concerning the geology of this country with the exception of the summary reports, 1906-1909, and the preliminary report on Telkwa river and vicinity by the writer.

SUMMARY AND CONCLUSIONS.

In general, the geology of the new districts visited this year, shows little variation from that of the neighbouring localities described in previous summary reports.

Rocks of the Hazelton (Porphyrite) group in all cases predominate in areal distribution, while a number of new areas (in most cases small) of the Bulkley eruptives were noted. Only one new area of the coal-bearing Skeena series was examined; it contains a number of coal seams; but it is doubtful if their quality is sufficiently good or the seams large enough to permit of coal-mining on a commercial scale.

A small area of Tertiary sediments was noted on Driftwood creek, being the first occurrence of these rocks seen in the district. They contain seams of lignitic coal which have been prospected to a certain extent during the past season; the results obtained, however, do not give much promise that they will be of value.

A number of coal claims have been staked, and a little work done on some black carbonaceous shales, containing streaks of coal, which occur low down in the Hazelton group, and outcrop at intervals for 30 miles along the lower reaches of the Bulkley river. It seems highly improbable that workable coal seams will be found in these shales.

As noted in previous reports the chief mineral deposits occur near the contact between rocks of the Hazelton group and the Bulkley eruptives, either in, or alongside of dykes from the latter, in fissures around the peripheries of the intrusive masses, or in sheared and crushed zones in the eruptives themselves. It seems clear, therefore, that it is in the immediate vicinity of these intrusive rocks that prospecting should be most thoroughly carried on.

Few new discoveries of note were examined during the past season, but prospectors are penetrating farther into the mountains every year, and vague reports were heard of the finding of new mineral bearing localities; notably on the Rochers Déboulés mountains, the headwaters of the Suskwa river, and Babine lake.

The silver-lead claims on Ninemile and Fourmile mountains, near Hazelton, were the centre of activity of the district, the various properties being energetically prospected and some development work being done.

A trial shipment of about 5 tons of ore was made from the Lead King, while the Silver Cup and Sunrise mines had jointly about 15 tons sacked and ready for shipment.

GENERAL CHARACTER OF THE DISTRICT.

The country is on the whole mountainous, although it is intersected by many comparatively wide and fertile valleys: such as those of the Bulkley, Kispiox river, and parts of the Skeena river and of Babine lake. The greater part of the district examined is drained by the Bulkley river, the largest tributary to the Skeena, which ocupies a wide valley with many open or slightly timbered areas, which are rapidly being settled. To the south and west, the watershed between the Bulkley and the Kitseguecla and Zymoetz rivers consists of the Rochers Déboulés mountains and the Hudson Bay mountains respectively; both of these are large isolated blocks of mountains, reaching elevations of from 7,500 to 8,000 feet, and are cut off on all sides by low valleys.

To the east and north, the Babine range divides the waters of the Bulkley from those of Babine lake. This range reaches its greatest height to the northeast of Hazelton, the highest peaks attaining elevations of 8,000 feet. About 10 miles above Hazelton the Suskwa river enters from the east, taking its rise in a comparatively low pass (3,500 feet). Southeast of the Suskwa the Babine range reaches heights of from 6,000 to 7,000 feet; until in the neighbourhood of Moricetown (30 miles from Hazelton), a region of much lower timbered ridges is met with, gradually rising again to culminate in a group of high, rugged peaks, in which head Twobridge, Driftwood,

and Cañon creeks—the chief tributaries of the Bulkley from the east—north of the Suskwa. From this point southeast the range gradually diminishes both in height and width.

The valleys of the Skeena and the Bulkley, and of the lower portions of the Suskwa and Telkwa rivers are, for the most part, terraced, and the rivers have in many cases cut through the ancient valley floors forming secondary, deep, cañon-like channels. This is particularly noticeable on the Bulkley, which flows in a cañon for nearly 30 miles from its mouth, with a total fall of about 1,000 feet in this distance.

The country is, on the whole, well wooded, the principal trees being spruce, poplar, jack-pine, balsam, and birch with a little hemlock and cedar.

General Geology.

TABLE OF FORMATIONS.

1. Quaternary..............	Glacial deposits.
2. Tertiary.................... (Oligocene?)	Sandstone, conglomerate, shale and coal.
3. Tertiary?................	Bulkley eruptives.
4. Lower Cretaceous........	Skeena series (coal-bearing).
5. Jurassic..................	Hazelton group.

DESCRIPTION OF FORMATIONS.

Hazelton Group.—These rocks were originally named by Dr. Dawson the 'Porphyrite Group' ; but this name was abandoned last year as being somewhat misleading. Where originally met with by Dr. Dawson, in the François Lake district and on the Skeena near Kitselas, they consisted almost exclusively of porphyrites; whereas in the vicinity of Hazelton, tuffs, sandstones, and shales, are extensively developed.

Generally speaking, it may be said that to the south, this formation is built up almost entirely of flow rocks, chiefly andesites, massive, and with characteristic dark red and green colours. At the top of the series, a few thin beds of fossiliferous sandstones and shales appear, a number of fossils from which have been determined to be of Jurassic or early Cretaceous age. These are overlain directly by the coal-bearing Skeena series, so that in the Telkwa River district little difficulty was encountered in separating these two formations in the field. On travelling northwards, however, it was found that these flows gradually thinned out, and were replaced by a considerable thickness of tuffs and tufaceous sandstones, although a few of the andesite beds extended as far north as Hazelton. Locally, these tufaceous beds are known as sandstones, and where altered near the contact with intrusive masses, as quartzites. A number of thin sections of these rocks were examined microscopically by Dr. G. A. Young, and in all cases were found to be of volcanic origin.

The best section available of these tufaceous rocks is to be found in the cañon of the Bulkley, from Hazelton to Moricetown, where, although the strata are highly folded and faulted, it is hoped that a fair estimate of their minimum thickness may be obtained.

Well down in the series, and intercalated with beds of purely volcanic material, a series of sediments occur which do not exceed 150 feet in thickness, but which are of importance, inasmuch as several beds of black carbonaceous shale, with thin streaks of coal contained therein, have been mistaken for coal, and many coal claims located on them. From the evidence on hand it seems improbable that workable coal seams occur in these shales. Typical exposures of these rocks can be seen in the Bulkley cañon near the mouth of Mud creek, and about 2 miles above the mouth of Boulder creek. A few fossils were collected from these beds, but they were so imperfectly preserved that it was found impossible to identify them. The similarity of these

sediments to those of the coal-bearing Skeena series, and the great amount of disturbance that the strata have been subjected to, entails very careful study before an opinion can be expressed as to the horizon of any given outcrop.

In the Babine range, at the headwaters of Driftwood cañon, and Twobridge creeks, the rocks of the Hazelton group consist chiefly of dark reddish, and greenish andesites, very similar to those seen on the Telkwa river, with this difference, however, that in the Babine they show, nearly everywhere, a certain amount of schistosity, whereas on the Telkwa they are always massive. This schistosity is also very apparent on the Bulkley river, in the neighbourhood of the mouth of Twobridge creek.

Roughly speaking, rocks of the Hazelton group underlie about four-fifths of the area under consideration, and, with the exception of the above mentioned shales and sandstones, are, as a rule, readily distinguishable from the other formations present.

From the Morice river northward to the vicinity of Moricetown they consist almost entirely of thick beds of massive, fine-grained andesites (usually either dark red or green in colour), but with some beds of tuff. From Moricetown to Hazelton the tufaceous beds predominate; which are generally rather fine-grained, and hard, and show well-defined bedding. They are usually light in colour with prevailing greenish tints.

Skeena Series.—This series is of great economic importance, inasmuch as all the known coal of commercial value is contained therein. The strata consist essentially of rather soft, thin-bedded shales and sandstones, the former, in places, carrying many clay-ironstone nodules and holding a number of coal seams. At the base of the series there is usually found a bed of coarse, crumbly conglomerate, but this, though fairly persistent, is not always present.

Owing to the disconnected nature of the exposures and the seeming lack of continuity of the beds, a complete section of these rocks has never been obtained. It seems probable, however, that their total maximum thickness is in the neighbourhood of from 600 feet to 800 feet. A number of fossils (chiefly plants) collected at various times, have been determined by Mr. Lawrence Lambe and Mr. W. J. Wilson, and show the age of these beds to be lower Cretaceous, and about equivalent to the Kootenay series of the Crowsnest pass.

The Skeena series is apparently conformable with the Hazelton group, and the line between them must be rather arbitrarily drawn, the coarse conglomerate already mentioned being regarded as the base of the Skeena series.

These beds occur in a number of comparatively small patches in various widely-separated localities, being folded in with the harder, underlying volcanics. These small isolated areas seem to be remnants of one or more large fields, which, owing to favourable circumstances, have escaped denudation. It is only in the valleys and low country that these rocks are now to be found, erosion having completely removed them from the higher ridges and mountains. The most important coal-bearing areas are situated on the Telkwa river and the headwaters of the Morice, which have been described in previous reports. Other important localities where they have been noted are on the Shegunia and Kispiox rivers. The only new area examined this season is situated on the Bulkley river near the mouth of Boulder creek, about 21 miles above Hazelton, where the beds occur in the form of a shallow, synclinal basin, with a number of minor undulations, the river cutting across it diagonally. The greatest width of this trough is probably not more than $1\frac{1}{2}$ miles, with a length of about $4\frac{1}{2}$ miles. The only outcrops occur in the banks of the river so that it is a matter of some difficulty to define the boundaries definitely. To the north the coal-bearing beds are cut off by a granitic intrusion, while at the southern extremity there is a faulted contact with rocks of the Hazelton group. A number of small coal seams have been uncovered here and a little prospecting has been undertaken.

Bulkley Eruptives.—These rocks, consisting chiefly of granodiorites and diorite porphyrites, have evidently played an important part in the deposition of the various mineral deposits in the district, since it is in the immediate neighbourhood of these intrusive masses that all the principal ore bodies have been discovered.

Numerous areas of these eruptive rocks are found at various points in the district, almost invariably accompanied by more or less mineralization near their contacts with the intruded volcanics. Among others examined during the past season is a comparitively small but important area situated on the headwaters of Tuchi river: a stream rising in the Babine mountains, and following easterly to Babine lake. It is near and along the contact of this granitic mass with tufaceous rocks and argillites of the Hazelton group that the claims of the Babine Bonanza Mining and Milling Company, as well as many others, are situated. Other important areas occur on the Bulkley river near Gramaphone creek, in the Babine mountains at the head of Sharp creek, and in the Rochers Déboulés mountains at the head of Boulder and Porphyry creeks; as well as the areas mentioned in previous summary reports on the Telkwa river, and on Ninemile, Sixmile, and Twentymile mountains. The rocks of this group vary greatly in texture and appearance, but are, as a rule, rather coarse grained, porphyritic, and grey in colour, although in a few localities pink colours prevail.

Nothing definite is known of the age of these rocks except that they are younger than the Skeena series; dykes from them cutting the coal measures at a number of places. They are here provisionally classified as Tertiary.

Tertiary Sediments.—On Driftwood creek (which enters the Bulkley about 45 miles above Hazelton), 2 or 3 miles above the Hazelton-Aldermere road crossing, a small area of soft conglomerates, sandstones, and shales occurs. Some of these beds contain many plant impressions, often well preserved, a number of which have been identified by Mr. W. J. Wilson as 'clearly belonging to the Tertiary formation, and being very common in the Oligocene.'

A number of seams of lignitic coal have been found in these beds, but where stripped, they are so banded with shales that it seems unlikely that they can be profitably mined.

The country in this neighbourhood being very heavily drift-covered, it was found impossible to trace the boundaries of this basin with any degree of accuracy, but its total extent is probably not more than 4 by 2 miles. The strata are usually very soft and readily-weathering, and the sandstones and conglomerates are very light in colour. In places, along Driftwood creek, the coal has evidently been burned, with the result that the clay shale, interbedded with the coal, has been baked to a hard, white, brick-like material, although at times very finely laminated.

Though unconformable with the underlying volcanics, these beds have been very highly flexed and faulted in places, although where the coal seams have been prospected the strata are nearly horizontal.

Economic Geology.

The Bulkley eruptives appear to have been the main factor in the deposition of mineral deposits in this district. All the important mineral-bearing localities are situated near the contact of these eruptives with rocks of the Hazelton group, either in or alongside of dykes radiating from the main masses, in fissures in the volcanics near the contact, or in sheared zones in the intrusive rocks themselves.

The coal seams have also been affected to a considerable degree by these rocks, as the quality of the coal appears to depend to a great extent on contiguity to these eruptive areas, becoming more anthracitic in character as they are approached. The seams have also, in places, been cut by dykes, often accompanied by faulting which will undoubtedly complicate future mining operations.

GROUPS OF DEPOSITS.

The copper and copper-silver deposits of the Telkwa river and the silver-lead properties of Hudson Bay mountain, have been briefly described in previous summary reports, and no new information is at hand this year in regard to them.

Prospecting has been actively carried on at the various silver-lead properties on Ninemile and Fourmile mountains, near Hazelton. It is expected that when adequate transportation facilities are obtainable on the completion of the Grand Trunk Pacific railway from Prince Rupert to this district, that several properties will be in a position to commence ore shipments.

Prospectors have been energetically at work in the Babine and Rochers Déboules mountains, and about the head of Suskwa river and Babine lake, as well as in many other localities, but nothing definite is yet known as to the results obtained.

Coal prospecting has been carried on with much activity, during the whole season, from the Morice river to the Kispiox valley, and many new locations have been made.

DESCRIPTION OF PROSPECTS.

The Babine-Bonanza Mining and Milling Co.—This property (better known as Cronin's mine) is situated in the Babine mountains near the headwaters of a branch of Tuchi river, a tributary of Babine lake, and not far from the sources of Driftwood creek. The locality is somewhat difficult of access by the present trail up Driftwood creek, as the summit at the head of that stream is high and rugged and passable with loaded pack animals only for a short season. It is expected, however, that a more favourable route, with no adverse grades, can be found by way of the Tuchi river and Babine lake.

The ore occurs at or near the contact of an area of pinkish granite porphyry, with a series of altered black argillites and tuffs of the Hazelton group. Along the contact the porphyry is much decomposed, and nearly everywhere more or less mineralized. It would appear that there are two classes of ore deposits on this property; the first, on which most of the work has been done, occurring in a sheared zone in the porphyry, and the second along the contact where the porphyry has in part been replaced by secondary minerals.

The ore consists essentially of crystalline galena and zinc blende in a gangue of quartz and brecciated porphyry; it also contains small quantities of iron, copper, and arsenical pyrites. No information is available as to the values contained in the ore.

The principal work done is a tunnel, driven along a sheared zone in the granite porphyry, with the intention of cutting an ore shoot exposed on the surface at the top of the hill, about 250 feet above the level of the tunnel. What is probably the continuation of this ore shoot, was cut about 350 feet from the entry, and showed 3·4 feet of good ore, consisting of galena and zinc blende in a quartz gangue, striking N 65 E, and dipping about 70° NW. A short way beyond this point the ore is cut off by faulting, the tunnel having been driven in barren ground a further distance of about 125 feet, and a cross-cut driven to the southeast for about 115 feet, without finding the ore. An upraise was driven on the ore for about 30 feet, where the vein was again found to be faulted.

On the surface a considerable amount of prospecting work has been done, consisting of open-cuts and several small shafts. An incline shaft sunk on the dip of the vein, in what is probably the same shoot as that found in the tunnel, shows about 3 feet of ore, but the vein is somewhat irregular. The whole width of the vein is fairly heavily mineralized with galena and zinc blende in a gangue of quartz and altered country rock, both walls consisting of granite-porphyry, and the foot-wall being heavily slickensided. The shaft is about 40 feet deep on the dip of the vein, which here is about 60° north.

About 450 feet to the southwest a vertical shaft has been sunk to a depth of about 20 feet. Although within a few feet of the contact, this shaft is entirely in the porphyry, and shows about 2 feet of ore: consisting of galena, pyrites, arsenopyrites, and much zinc blende, in a gangue of brecciated porphyry and quartz. Alongside of this shaft and adjoining it a slope has been sunk on the contact between the granite-porphyry and the black argillites, the foot-wall being porphyry and the hanging wall argillite. The dip is here 70°, and the ore about 4½ feet wide and similar to that in the shaft. This slope is about 28 feet deep on the dip of the ore.

It does not seem probable that the ore body here has any connexion with that found in the tunnel, but is rather a separate contact deposit. Continuing in a southwesterly direction along the contact, a number of open-cuts and shallow shafts show ore more or less continuously for a distance of about 1,500 feet.

Ste. Anne and St. Eugene Mineral Claims.—These claims, the property of John McKendrick and partners, are situated in the Babine mountains near the headwaters of Cañon creek, but on the Babine Lake side of the divide, and at an elevation of about 5,000 feet above sea-level.

The ore occurs in a well defined vein in an intrusive area of what is probably a granodiorite, but which has not yet been microscopically examined. These granitic rocks cut the volcanics of the Hazelton group, and consist chiefly of green and red andesites and breccias. The vein occurs near the contact of the two formations.

The ore consists of white and rusty quartz, with tetrahedrite and galena, which occur, as a rule, more or less concentrated in bands parallel to the walls of the vein. The writer was unable to obtain any definite information in regard to the assay value of the ore.

With the exception of a few open-cuts, the only development work done on this property consists of a tunnel 50 feet in length, driven on the vein, which, in the face of the tunnel, has a width of 4·4 feet.

Last Chance and Little Wonder Claims.—Last Chance and Little Wonder mineral claims, owned by Brewer Bros., are situated at the head of the south fork of Boulder creek, a stream which flows into the Bulkley river about 21 miles above Hazelton. An important area of granitic rocks occurs in this neighbourhood, extending southwards to the north fork of Moricetown-Twomile creek, and northwards to the head of Mud creek; cutting the red and green andesites of the Hazelton group.

The claims are located in the granitic rocks, but quite close to their contact with the volcanics, the mineral being deposited along a crushed and sheared zone. The only work seen consisted of a couple of open-cuts which exposed about 16 feet of ore consisting of pyrites, a considerable admixture of tennantite, and some chalcopyrite, in a gangue composed of quartz and decomposed granitic country rock. Many small seams and lenses of quartz are in evidence, usually in bands parallel to the walls, and frequently showing comb structure with many exceptionally large quartz crystals developed. The walls are not clearly defined, but merge gradually into the granitic wall rock, which is much decomposed for some distance on each side of the ore body.

The strike of the lode is about southwest and the dip 45° northwest.

The writer was unable to obtain any information in regard to the values contained in this ore.

Silver Cup Mines Limited.—A brief description of the claims of this Company, which are situated on Ninemile mountain, near Hazelton, was given in the Summary Report of 1909. Since then, a considerable amount of work has been done on the property, and about 15 tons of ore sacked, ready for shipment for a smelter test.

Three tunnels have been driven, in each case on the vein, which show a total difference in elevation of at least 1,000 feet. The upper tunnel is about 200 feet in length and shows some ore all the way, while the second tunnel, about 150 feet below the first, has been driven a distance of 65 feet in ore averaging about 2½ feet in width.

The lower tunnel had only been started at the time of the writer's visit, and had not at that time reached solid rock.

Sunrise Group.—This group, situated on Ninemile mountain, was also described in last year's Summary Report, and since then has been actively prospected. The main vein occurs in a granitic (granodiorite) intrusion; the ore, consisting of galena with a little stibnite and zinc blende, being deposited in a sheared zone. The vein has been stripped for about 150 feet on a very steep hillside and shows about 3 feet of quartz, and disseminated galena, and from 6 to 15 inches of solid galena. The sheared zone containing the ore is from 10 to 25 feet in width, and is generally more or less mineralized; and it is possible that part of it at least will prove of shipping quality.

A short tunnel was being driven to cut the vein below the lower end of the stripping, but at the time of the writer's visit had not yet reached the ore, in a distance of 30 feet.

About 16 tons of picked ore was sacked and ready for shipment before the close of navigation on the Skeena.

Silver Pick Group.—This group of three claims is also situated on Ninemile mountain, to the east of the Sunrise group. The ore occurs in a number of roughly parallel veins, in highly altered tufaceous rocks of the Hazelton group, and near their contact with the main granitic intrusion of Ninemile mountain. It appears probable that the ore deposition has taken place along the bedding planes of the tuffs, the original country rock having been replaced in part by quartz and ore. With the exception of a little surface stripping, no work has been done on these claims. Four veins, varying from 2 feet to 3 feet in width, have been exposed, all of which are very similar in appearance, the ore consisting of disseminated galena with a little zinc blende and stibnite in a quartzose gangue. The writer was informed that a number of assays obtained by the owners showed returns of from $19 to $125 in combined silver and lead values.

COAL.

Morice River Areas.—On the Morice River waters three known areas of coal lands, situated respectively on the main Morice, on the Clarkford and on Goldstream (a tributary to the latter), have been energetically prospected by Messrs. Jefferson and Dockrill. These areas have been described in previous reports. Two diamond drills, one operated by hand power and the other by steam, were in service most of the season; unfortunately a forest fire damaged the larger machine, necessitating, for some time, a cessation of operations.

The writer was unable to get any details of the results attained, but was assured by Mr. Dockrill that in the Goldstream basin a large area of excellent coal had been proved.

Grand Trunk Pacific Railway Company's Coal Lands.—Considerable prospecting has been carried on by this Company during the past season on their coal locations situated on the Telkwa river and its tributaries, Mud and Goat creeks.

A number of short tunnels were run on the seams outcropping on Mud creek. The first of these (No. 1) was driven near the northeastern edge of the synclinal trough in which the coal measures lie. At the point of entry, on the southeast bank of Mud creek, the seam was nearly horizontal, but on driving, it was found to have a light southwesterly dip which, at 118 feet from the entry, brought the coal to the surface again. The seam is 3·9 feet in thickness, and is overlaid by 3 feet of shale followed by 3 feet of coal. The lower bench appeared to be good, clean, firm coal, and an average sample taken from near the face of the tunnel gave the following analysis:—

	Per Cent.
Moisture	2·35
Volatile combustible matter	27·72
Fixed carbon	60·65
Ash	9·28

Coke firm and coherent.

No. 2 tunnel, also driven from the southeast bank of Mud creek, but about 400 yards above No. 1 tunnel, opened up a 4 foot seam of coal for a distance of 140 feet. The coal here, however, is rather severely disturbed and much crushed.

On Goat creek an attempt was made to sink a slope on a 9 foot seam of what appears at the surface to be good, clean coal. The slope was started near the level of the creek, but had to be abandoned on account of flooding.

Two diamond drills had been ordered by this Company, but up to the middle of September had not started operations, although at that time it was hoped to begin work within a few days.

The Ashman Coal Mines Limited.—This Company holds twelve sections of land as local locations on the Bulkley river between Boulder creek and Moricetown-Two-mile creek. This area is underlaid by rocks of the Hazelton group, consisting chiefly of tufaceous sandstones, tuffs, and some andesitic flows. There are, however, several beds of shaly sandstones and carbonaceous shales with thin irregular streaks of coal, and it is due to the presence of an 11 foot bed of carbonaceous shale and its resemblance to coal that these lands were located. The bed in question outcrops in the deep, cañon-like channel of the Bulkley, near the mouth of Swamp creek (a small tributary of the Bulkley entering that stream about 23 miles above Hazelton), where it strikes S 18° W with a dip of 60° NW. It is about 11 feet in thickness, has been stripped at several places, and a short tunnel driven on it from near the level of the river. The following analyses, by the Mines Branch, Department of Mines, from average samples taken at different times, will show that this can hardly be classed as a true coal; but rather as a carbonaceous shale:—

—	No. 1.	No. 2.	No. 3.
Moisture	1·91	1·73	2·04
Volatile combustible matter	10·79	12·38	10·40
Fixed carbon	20·50	37·98	23·86
Ash	66·80	47·91	63·70

All the rocks of the Hazelton group, from this point to Moricetown, are much folded, and many faults may be seen.

The Grand Trunk British Columbia Coal Company, Limited.—The property of this Company, consisting of twelve claims, is situated on the Bulkley river about 20 miles above Hazelton. The coal beds of the Skeena series are here found in a rather shallow but fairly regular basin, with a total length of about 4½ miles, and a maximum width of probably not more than 1½ miles.

A number of small coal seams were stripped some years ago at the northwestern extremity of the basin, when a total of eleven seams were uncovered, ranging from 12 to 40 inches in thickness, and included in about 500 feet of sandstones and shales. The following analyses from two of the best looking of these seams proved disappointing, the percentage of ash being very high:—

——	Moisture.	Vol. Comb.	Fixed Carbon.	Ash.
No. 1—15 inch seam	1·02	25·70	52·96	20·32
No. 2—18 inch seam	1·39	25·56	50·06	22·99

Coke in both cases firm and coherent.

Near the centre of the basin the Company has stripped six seams, varying from 12 to 38 inches in thickness, and probably representing in part the above-mentioned seams. The strata at this point are very regular, the strike being S 40° E, and the dip 30° to the northeast.

The following analyses, by the Mines Branch, of samples from three different seams, show an unduly high percentage of ash:—

——	Moisture.	Vol. Comb.	Fixed Carbon.	Ash.
No. 1—20 inch seam	1·12	23·70	51·72	23.46
No. 2—38 inch seam	2·15	22·03	43·66	32·16
No. 3—20 inch seam	1·36	25·18	55·41	18·05

Coke in Nos. 1 and 2 firm and coherent.

Coke in No. 3 coherent, but tender.

This coal differs considerably in appearance from that of the Telkwa river. It is very hard, is finely laminated, and shows a very distinct cleavage at right angles to the bedding planes.

Driftwood Creek Coal.—This area of coal bearing rocks has been known for a number of years, but it was during the past season only that any claims have been located thereon. The coal seams occur in a comparatively small patch of Tertiary sediments—probably not more than 4 by 2 miles in extent—although its boundaries have not been closely defined: On part of the area the coal has been burned, baking the interbedded clay shales to a whitish brick-like material.

The Tertiary rocks are found outcropping in the valley of Driftwood creek, about 2 to 3 miles above the crossing of the Hazelton-Aldermere wagon road. An open-cut in the bank of Driftwood creek shows this section.

	Feet.
1. Grey and carbonaceous shale and a little coal	5·00
2. Fairly clean coal	1·80
3. Coal and dark shale	4·40
4. Dark clay shale and a little coal	3·60

In Nos. 3 and 4 of this section, the coal and shales alternate in very narrow beds, never more than an inch or two in thickness, the shales themselves being usually highly carbonaceous.

The analyses here given are from the 1·8 feet of clean coal (No. 2), and from an average sample from 6·2 feet of combined coal and shale (Nos. 2 and 3):—

——	Moisture.	Vol. Comb.	Fixed Carbon.	Ash.
No. 1—1·8 feet fairly clean coal	7·90	36·64	42·06	13·40
No. 2—6·2 feet banded coal and shale	7·39	31·88	28·07	32·66

In No. 1 the coke was non-coherent, while in No. 2 it was coherent but tender.

The above analyses show the coal to be of lignitic character. In picked specimens it is hard and bright, with a conchoidal fracture, but it is extremely doubtful whether a workable thickness of coal clean enough for market purposes will be found here. Several small seams varying from a few inches to one foot were noted below this one.

KITSALAS DISTRICT.

On returning down the Skeena river to Prince Rupert a short stay was made at Kitsalas village, situated at the foot of the cañon of the same name and about 60 miles below Hazelton. From Kitsalas a fair trail leads up Gold creek to its head, then descending into the valley of the Zymoetz river it continues up a branch of that stream to the Telkwa pass, from which point it follows the Telkwa river down to Aldermere on the Bulkley.

Near the Gold Creek-Zymoetz River divide, a number of claims have been staked, but very little development work has so far been attempted.

The geological conditions here are very similar to those of the upper Telkwa river, the predominant rocks belonging to the Hazelton group, and consisting chiefly of red and green andesites with some breccias and tuffs. These rocks are cut by several granitic intrusions (probably Tertiary), but it is possible that all the granitic rocks to be seen here are not contemporaneous, some of them at least being most probably referable to the older Cascade Crystalline series of Dawson, denudation having removed the overlying volcanics in places. The similarity of these two series of granitic rocks, however, would necessitate a much closer study of them than could be made this year, in the short time available, before any definite classification could be undertaken.

The 'Avon group' of three claims, owned by Messrs. Olesen, Burns, and Lowery, is situated near the head of Gold creek. The country rock is a green andesite, lying nearly horizontal and much altered in places. The ore occurs in what appears to be a dyke from an intrusive granitic mass to the east, the dyke having a width of 40 feet and striking S 25° E with a dip of 70° NE. The ore consists of chalcocite, bornite, chalcopyrite, pyrites, blende, and copper carbonates, in a gangue of altered dyke rock, garnets, quartz, epidote, and calcite, and occurs scattered throughout the dyke, but seemingly more or less concentrated in the neighbourhood of the walls.

The Wells Group.—The 'Wells group' is situated on the Zymoetz River slope near the head of Gold creek, at an elevation of about 4,600 feet above sea-level. The country rock here consists of red and green andesitic flows, which strike about N 30° E and dip 50° to the southeast. The ore occurs along the walls of, and in places disseminated through, a dyke about 30 feet in width, which has a strike of N 30° W and a dip of 60° to the southwest. The mineralization appears heavier along the southwest wall, but the whole of the dyke rock has been more or less replaced with ore. A width of about 2 feet along the southwest wall shows considerable quantities of chalcocite and copper carbonates in a gangue of calcite, quartz, and decomposed dyke rock.

GEOLOGY OF THE VICTORIA AND SAANICH QUADRANGLES, VANCOUVER ISLAND, B.C.

(Charles H. Clapp.)

The greater part of the field season of 1910 was spent in a detailed geological examination of a district in the vicinity of Victoria, Vancouver island, B.C. The topographic maps prepared by R. H. Chapman in 1909 were used as field maps. These maps consist of two fifteen minute sheets, the Victoria and the Saanich quadranges, mapped on a scale of 1:48,000 (1 inch=4,000 feet) with 20 foot contours. The total land area represented is about 150 square miles, and includes the southeastern part of Vancouver island, the region adjacent to the city of Victoria, the Saanich peninsula, and the southern part of Saltspring island, and several smaller islands in Haro straits. The detailed geological work on the Victoria and Saanich quadrangles was completed by the middle of September. The rest of that month, and the first part of October, were spent applying the results reached during the detailed work to the geology of the whole southern end of Vancouver island, over which reconnaissances had been made during the seasons of 1908 and 1909.

I was very ably assisted in the detailed work, and in part of the reconnaissance work by Mr. John D. MacKenzie and Mr. Alexander G. Haultain.

PREVIOUS WORK.

Very little detailed geological work had been done in the Victoria and Saanich quadrangles. In the seventies, Selwyn, Richardson, and Dawson made reconnaissances in the neighbourhood of Victoria. In 1908 I made a general reconnaissance over the southeastern part of Vancouver island, including virtually the entire area mapped during the present field season, the results being published in the Summary Report for 1908.

SUMMARY AND CONCLUSIONS.

The larger part of the Victoria and Saanich quadrangles is underlain by crystalline rocks. These belong to two, or possibly three groups. The older groups consist of metamorphosed basic volcanic rocks, with intercalated lenses of crystalline limestone. They have not only been folded, faulted, and dynamo metamorphosed, but also contact metamorphosed by the younger group, which consists of intrusive plutonic rocks. The larger part of the metamorphic rocks belong to the Vancouver group, and are lower Jurassic, and in part probably Triassic in age. Some of the volcanic rocks near Victoria and Esquimalt are more metamorphosed than the greater part of the Vancouver group, and may be Palæozoic in age.

The intrusive batholithic rocks may be divided into three principal types, which were erupted in a definite sequence as follows: diorite gneiss, quartz diorite gneiss, and granodiorite and quartz diorite. The two older types have been greatly dynamo metamorphosed, and also somewhat contact metamorphosed by the later granodiorite intrusions. As a whole the batholithic rocks belong to one general period of eruption, and are correlated with the upper Jurassic, Coast Range batholith.

Unconformable on the old crystalline rocks occur the upper Cretaecous sediments. These sediments, which belong to the Nanaimo formation, occur in the northern and eastern part of the Saanich quadrangle in two synclinal basins.

The larger part of the area is covered by superficial deposits of glacial origin. They have, however, been worked over by post-glacial rivers and marine agencies so that the deposits are now usually stratified.

The mineral resources of the quadrangles are confined to non-metallic deposits, lime, cement, clay, sand, gravel, and crushed stone.

General Character of the District.

TOPOGRAPHY.

The relief of the area represented by the Victoria and Saanich sheets is generally low, ranging from sea-level to 1,940 feet on Saltspring island, and to 1,440 feet, the top of Mt. Wark, on Vancouver island. The average elevation in the eastern part of the area is from 200 to 300 feet above sea-level, and in the Highland district, in the west central part of the area, is from 600 to 1,000 feet above sea-level. The higher elevations are knob-like hills, which rise several hundred feet above the general level.

A peculiar feature of the relief is the long ridges of stratified sand, gravel, and clay which occur in the eastern part of the Saanich peninsula, and on James and Sidney islands. They are in certain cases 2 miles long, 100 to 200 feet high, and esker-like in form.

Although the relief is low, there are no plains of any great extent. The Colwood plain, and the basins underlain by stratified clays and sands in the neighbourhood of Victoria and Sidney, are relatively flat, but are only 2 miles or less in width.

There are no large rivers in the area, but there are many small creeks, the greater number of which are dry during the summer months. Small lakes are numerous in the southern and western districts, and occur chiefly in wide, pre-Glacial valleys, with drift divides. In detail the valleys are irregular, but in general they have either a north-south or a northwest-southeast trend.

The coast line of Vancouver island is very irregular, and there are a large number of relatively small islands near the main island. Steep, wave-cut cliffs of sand and gravel, up to 200 feet high, occur, usually with attendant sandspits and bars.

In the eastern part of the area, in pre-Glacial time, the erosion cycle, initiated by the uplift of a peneplain developed by a Tertiary erosion cycle, reached old age, and the only elevations remaining at present are rounded, monadnock-like hills. In the Highland district, however, the Tertiary peneplain although maturely dissected is still represented by flat-topped and ridge-like hills, which are interrupted by rather narrow but deep valleys. It appears as if the whole area at some time subsequent to the mature dissection of the Tertiary peneplain was depressed, thus forming the drowned coast line of the present day.

The topography was greatly modified during the Glacial period; the monadnock-like hills were rounded, the valleys deepened and widened, thus changing the drowned valleys to typical fiords, and the country was covered by a heavy mantle of drift. The glacial drift was worked over by post-Glacial rivers and deposited in lakes and marine basins. It is probable that an elevation of comparatively recent date brought the stratified sands and gravels above sea-level.

CLIMATE AND VEGETATION.

The temperature of the region is remarkably uniform throughout the year, averaging about 55° F in summer and 40° F in winter. The rainfall is much less than in other portions of the north Pacific coast, owing to the occurrence of high mountains on all sides. It averages less than 35 inches. The greater part of the rain falls in the winter months, while the summer is very dry.

The region was once heavily forested, but the forest trees, largely conifers, have been cut over a large part of the area. Fruit, especially berries of various kinds, is the

chief agricultural product. The higher and more rocky parts of the area are still covered with the dense timber and thick underbrush so characteristic of Vancouver island and the north Pacific coast.

MEANS OF ACCESS.

The area has many wagon roads, and is traversed by two railways, the Esquimalt and Nanaimo, and the Victoria and Sydney. An electric tramway has been projected along the Saanich peninsula. The roads, and the large amount of cleared land, make the area very accessible, and as rock outcrops are abundant, the geology may be done with a minimum amount of physical labour. The elucidation of the geology of the area is important, since it is representative of the geology of the whole island, and in fact of the coast region of British Columbia.

GENERAL GEOLOGY.

TABLE OF FORMATIONS.

Superficial deposits	Pleistocene and Recent.
Nanaimo formation	Upper Cretaceous.
Dyke and batholithic intrusives	Upper Jurassic.
Porphyrites	
Granodiorite and quartz diorite	
Quartz diorite and diorite gneisses	
Vancouver group	Lower Jurassic and probably Triassic; and may include upper Palæozoic.

GENERAL DESCRIPTION OF FORMATIONS.

Vancouver Group.—The larger part of the volcanic rocks of the Saanich and Victoria quadrangles, with their associated limestones, notably those on the Saanich peninsula and neighbouring islands, undoubtedly belong to the Vancouver group. A belt of limestone lenses may be traced from Saanich inlet northwest to Cowichan lake, where a large number of fossils were collected in 1909[1], and which have been identified by Professor H. W. Shimer and myself. The species are all new, but the fauna is very definitely assigned to the lower Jurassic. In another lens of limestone, in the same belt, near the forks of Robertson river, 6 miles south of Cowichan lake, remnants of fossils were found, which appear to be similar to, or identical with, those identified. The structural relations of all the limestones in the belt are similar, and the volcanic rocks with which they occur are virtually continuous, so that it is almost certain that the limestones and volcanics of the belt are at least of the same general age, that is lower Jurassic.

The only important lens of limestone belonging to this belt, in the Saanich quadrangle, occurs near Tod inlet. The limestone is a compact, bluish grey marble, altered more or less by constant metamorphism, and is quarried and utilized for the manufacture of Portland cement by the Vancouver Portland Cement Company. Another much smaller deposit of limestone occurs on the shore of Cordova bay.

The associated volcanics are metamorphosed fragmental and flow rocks, basaltic and andesitic in composition. In places they have been silicified by contact metamorphism. They are commonly green weathering, greatly fractured, and often seamed with quartz and epidote stringers. Red weathering rocks, usually the fragmental types, are also characteristic.

The principal area of the volcanic rocks extends from the Saanich inlet, where the belt is over $2\frac{1}{2}$ miles wide, to Cordova bay, where the belt is over 3 miles wide,

[1] Summary Report, 1909. Geological Survey, Canada, p. 87.

although in the neighbourhood of Elk lake it narrows to less than a mile. Along the south shore of Shoal harbour there is another area of meta-volcanics, which probably forms a continuous belt extending to the southern end of Sidney island.

In the vicinity of Victoria there is a group of limestones and associated volcanic rocks, which although structurally similar to those described above are more altered and metamorphosed, and may be older. The limestones vary from white, coarsely crystalline marble to bluish compact marble, the more coarsely crystalline varieties predominating. Where unsilicified they are very pure, varying from 90 to 100 per cent $CaCo_3$. They occur in lens-like masses, chiefly in the vicinity of Esquimalt harbour, although one very small lens occurs on the north shore of Victoria harbour. The largest limestone mass, which extends from the west shore of Esquimalt harbour to the Colwood plain, is only a mile and a half long by a fourth of a mile wide. The other lenses are much smaller, from half a mile in length to mere inclusions in the volcanic rocks.

The volcanic rocks, originally andesites and basalts, have been converted by contact and dynamo metamorphism into silicified and epidotic rocks, or more rarely to typical greenstones. There are two principal areas of these volcanic rocks, one, pinching out to the west, extends from Gonzales point west to Clover point and north to Oak bay; the other, which is the larger, occurs in the vicinity of Esquimalt harbour, extending as far north as Thetis lake and westward to Colwood plain. Another much smaller area occurs at Knockan hill, and other very small masses occur in the intrusive plutonic rocks.

The volcanic rocks of the Vancouver group are intrusive into the limestones, sending dykes into them, and brecciating them along the contact. In a large sense, however, the limestones are considered as contemporaneous with the volcanic rocks. Both rocks have been intruded by the plutonic rocks of the upper Jurassic batholiths.

While it is most probable that all the volcanic rocks and associated limestones are Mesozoic in age, and belong to the Vancouver group, it is possible that more metamorphosed types are Palæozoic. If this were true they would belong to the Victoria group.[1] It has been shown, however, by the detailed work of the past season, that the larger part of the rocks which were thought in 1908 and 1909 to belong to the Victoria group are either members of the Vancouver group, or metamorphosed plutonic rocks. It seems best, therefore, until definite evidence of the Palæozoic age of some of the rocks has been found, to consider them all as belonging to the Vancouver group.

Exposed on the southern end of Saltspring island, and extending across Russell and Portland islands to Moresby island, are a series of schists and interbedded volcanic rocks. The schists, which are chiefly quartz, chlorite schists, are largely of volcanic origin, but some fairly typical slates and greywacks, undoubtedly sedimentary, are present. The rocks of volcanic and of sedimentary origin could not be separated in the mapping, and so are grouped together and mapped as a single unit. These rocks were first met with, in 1908, on Mt. Sicker, and have been traced eastward to Saltspring island. They have been called the Mt. Sicker formation,[2] and are one of the formations making up the Vancouver group.

Intrusive into the Mt. Sicker formation are large irregular bodies of andesite and diorite porphyrite, which though they may be related to the batholithic rocks, intrusive into the Mt. Sicker formation, are apparently related to the volcanic members of the formation itself.

On Albert head occur volcanic rocks of diabasic habit, which form part of the belt extending to the west coast, and which have been called the Metchosin volcanics.[3]

[1] C. H. Clapp, Summary Report, 1909, Geological Survey, Canada, p. 87.
[2] C. H. Clapp, Summary Report, 1908, Geological Survey, Canada, p. 56.
[3] C. H. Clapp, Summary Report, 1909, Geological Survey, Canada, p. 89.

The rocks of Albert head include flow rocks, amygdaloids and porphyries, dyke rocks, and tuffs and agglomerates. The fragmental varieties are largely stratified and the fragments water-worn. The rocks are far less altered than any of the other volcanic rocks of the region, and though provisionally assigned to the Vancouver group, are apparently younger. No evidence as to their age is given by their structural relations, as these are obscured by the thick deposit of sand and gravel of the Colwood delta. To the west of the area they are known to be separated from the Leech River slates to the north by a profound and extensive fault.

Dyke and Batholithic Intrusives.—Intrusive into all of the above formations, with the exception of the Metchosin volcanics, are large masses of plutonic rocks and their accompanying dykes. The plutonics were erupted during one general period of batholithic intrusion, but in detail may be divided into three types which were erupted in a definite sequence. The three groups are, in order of their eruption, diorite gneiss, quartz diorite gneiss, and granodiorite and quartz diorite. As indicated by their names, the first two types have been greatly dynamo-metamorphosed, and have been converted into gneisses. Although the granodiorite and quartz diorite are somewhat gneissic in structure, they are not typical gneisses. All of the above rocks have been considerably altered and fractured.

The diorite gneiss and quartz diorite gneiss are very intimately related, and form virtually a single batholith. The batholith extends from the southern end of Saanich inlet, in the neighbourhood of Mt. Wark, southeast across the Highland, Lake, and Victoria districts to the east shore of Vancouver island; and the diorite gneiss also occurs on Chatham and Discovery islands. The older type, the diorite gneiss, is fairly uniform, and is composed chiefly of plagioclase feldspar and hornblende, with more or less biotite. It ranges from fine to coarse grained, and is typically medium to coarse grained. The composition varies, sometimes the feldspar and at other times the hornblende predominates, and it also passes into hornblende gneisses or amphibolites. Although relatively large masses of typical diorite gneiss occur, as on Mt. Wark and north of Cadboro bay, it is nearly everywhere cut by numerous apophyses of quartz diorite and quartz-feldspar gneisses. Often a complex of the diorite and quartz diorite gneisses has been formed, in which the two types can not be mapped separately.

The quartz diorite gneiss forms long lenticular masses which are intrusive into the diorite gneiss, so that a series of alternating irregular belts of the two rocks is formed. The series has a strike of N 50° to 60° W.

The gneisses have not only been dynamo-metamorphosed but also contact-metamorphosed, the metamorphism having greatly affected the quartz diorite. In its recrystallization the light and the dark coloured minerals have been segregated in zones, from less than an inch up to several feet in width; so that the formation has a characteristic banded appearance. These banded rocks were thought by Dawson,[1] and in 1908 by the writer[2], to be partly metamorphosed sedimentary and volcanic rocks, but the microscopic study and detailed field work have shown conclusively their igneous and plutonic origin.

The larger part of the Saanich peninsula is underlain by a fairly uniform body of granodiorite, growing more basic in places and grading into a quartz diorite. This body of granodiorite is relatively unmetamorphosed, and is quite distinct from the gneissic rocks to the south, although it is very similar in composition to the quartz diorite gneiss. It is separated from the Wark and Victoria gneisses by a belt of volcanic rocks, but some of the aplite and other salic granitic apophyses in the gneisses are doubtless referable to the Saanich batholith. Another granodiorite stock occurs at the southern end of the Esquimalt peninsula. It is clearly intrusive into the diorite gneiss, the contact being marked by an extensive shatter breccia.

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[1] G. M. Dawson, Geological Record of the Rocky Mts., in Canada. Bull. Geol. Soc. Am Vol. 12, 1901, p. 72.

[2] C. H. Clapp, Summary Report, 1908, Geol. Survey, Canada, p. 55.

Associated with the plutonic rocks, notably with the Saanich batholith, are andesitic dyke rocks and other porphyrites, which are holocrystalline and range from basic to very acid, quartz-bearing varieties. They are irregular in composition, and are confined in their occurrence to the contact zones.

All the batholithic rocks belong to the same general period of intrusion. They are known to be intrusive into lower Jurassic rocks, and the upper Cretaceous measures rest unconformably upon them. They are, therefore, correlated, with considerable certainty, with the Coast Range batholith of British Columbia, which is upper Jurassic in age.

Nanaimo Formation.—The unmetamorphosed sedimentary rocks of the southern part of Vancouver island, which are referable entirely, or in large part, to the Cretaceous, have been grouped together, since they have not yet been definitely subdivided, and have been called the Cowichan group.[1] The rocks belonging to the Cowichan group, which occur in the Saanich quadrangle, probably all belong to one formation, or at least one series, which has been named and described by Richardson, Whiteaves, and Dawson as the Nanaimo series.[2] The rocks consist of conglomerates, sandstones, and shales, the sandstones greatly predominating. With them occur a few thin seams and lenses of a fair grade of bituminous coal.

The greater part of the Nanaimo formation occurs in the Cowichan basin, as defined by Richardson.[3] The rocks of this basin occur in a close folded syncline overturned to the south, so that the beds have a general dip to the north. The strike ranges from N 45° to 90° W. Several smaller folds occur in the major syncline. The north boundary of the basin is a thrust fault, and many smaller faults occur. The rocks of the syncline occur on the southern end of Saltspring island, and extend across the northern end of the Saanich peninsula to Bare and Low islands to the east of Sidney island, and are exposed on several small islands off the east coast of Vancouver island.

On Saltspring, Russell, Portland, and Moresby islands occur relatively small sedimentary areas, which belong to the Nanaimo formation, and which occur in the Nanaimo basin. The southwest shore of Pender island consists of thick bedded coarse conglomerates, which also belong to the Nanaimo basin.

Superficial Deposits.—A very large part of the area is covered by unconsolidated superficial deposits of various kinds, which are, however, almost entirely referable to the glacial period. Unmodified glacial till is comparatively rare below an elevation of 250 feet above sea-level. Above that level it occurs on Saltspring island, and in the Highland and Lake districts. As it occurs on steep slopes it has been more or less modified by sliding, and the removal of the finer material. Unmodified drift also occurs below 250 feet, resting unconformably on stratified drift.

The superficial deposits consist chiefly of stratified gravel, sand, and clay, and are principally fluviatile, lacustrine, and marine deposits. The material which was thus deposited was, however, derived from glacial till. The most extensive are probably lake or estuarine deposits and consist of stratified yellow and greyish blue clay, overlain to a considerable extent by sand and thin beds of gravel, with rounded glacial boulders up to 10 feet in diameter irregularly scattered through the deposit. The country underlain by these deposits is flat or gently undulating, and is generally covered by thick loamy soil, and forms, therefore, good farming land.

Undoubted river deposits of sand and gravel occur, with delta structure, and well developed terraces. The best example is Colwood plain, which is a delta deposit,

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[1] C. H. Clapp, Summary Report, 1909, Geol. Survey, Canada, p. 89.

[2] James Richardson, Report on the Coal Fields of Nanaimo, Comox, Cowichan, Burrard Inlet, and Scoke, B.C. Geol. Survey, Canada, Rept. of Progress, 1876-77, pp. 160-192.
J. F. Whiteaves. Mesozoic Fossils, Vol. I, Part II, Geol. Survey, Canada, 1879, pp. 93-96.
G. M. Dawson. The Nanaimo group. Am. Journ. Sci. Vol. 39, 1890, pp. 180-183.

[3] James Richardson. Geol. Survey, Canada. Rept. of Progress, 1876-77, pp. 187-188.

built up by a very large, post-glacial river. In the south Saanich district, and on James and Sidney islands are four parallel, esker-like ridges, 100 to 200 feet high, one-fourth of a mile wide, and which have a trend of about N 15° W. The two western ridges apparently extend, although not continuously, across Lake district to the eastern part of Victoria district. The origin of these ridges is at present obscure.

Another peculiar type of deposit occurs to the south (the lee side) of the knob-like hills north of Victoria. They are esker-like in shape and form long trains extending south from the hills, in the case of the Mt. Douglas train, for over a mile. They are composed of stratified sands and gravel, the sand predominating, and are cross-bedded and apparently have been deposited by flowing water.

Recent alluvial deposits occur in small depressions and in the river valleys. Along the shore, especially in the vicinity of the wave-cut cliffs of stratified sand and gravel, large sand bars have been built, some of which form barrier beaches, behind which occur lagoons and salt marshes.

Economic Geology.

The mineral deposits of economic value are entirely non-metallic; the products derived from them include lime and cement, brick and tile, sand and gravel, and crushed stone. More or less prospecting for metals has been carried on, chiefly for gold and copper.

GOLD AND COPPER.

The deposits which have been prospected for gold are chiefly the quartz-feldspar veins which accompanied the intrusion of the batholith rocks, and are not likely to carry gold in commercial quantities. Quartz veins such as occur in the Leech River slates to the west, and which are known to be gold-bearing, do not occur. Small veins carrying pyrite and chalcopyrite occur in the sheared zones of the meta-volcanics which illustrate the occurrence of copper ores in other parts of the island,[1] but which are not of themselves important. In the Mt. Sicker schists, on Saltspring and Moresby islands, pyrite and chalcopyrite occur, impregnating shear zones. In the Highland and Esquimalt districts, near the contacts of the plutonic rocks with the limestones and meta-volcanics of the Victoria and Vancouver groups, occasional contact deposits have been developed. They are similar in their occurrence to those to the west, described last year, but none of them are of commercial importance, on account of their small size and irregularity. An interesting feature of these deposits is the development of garnet in a contact metamorphosed volcanic rock.

COAL.

The occurrence of small seams and lenses of coal in the measures of the Nanaimo formation has attracted very considerable attention, chiefly on account of their proximity to the productive coal seams of the Nanaimo and Comox districts. One or two attempts have been made to mine the exposed seams, and some diamond drill boring has been carried on, as yet without successful results. The conditions are not very favourable; though the measures are well exposed along the shores of the various islands, no thick or extensive seams are known to occur; the measures are thick, fully 6,000 feet and more, probably 10,000 feet; they have been folded and faulted to such an extent that the dips are high, and the known coal seams occur near the base of the formation, so that the coal horizons probably occur chiefly at great depths.

LIME AND CEMENT.

The limestones of the Victoria and Vancouver groups yield excellent material for the manufacture of lime and cement since they are almost pure calcium carbonate.

[1] See Summary Report, 1909. Geol. Survey, Canada, pp. 91-94.

The stratified glacial clays are suitable to mix with the limestone for the manufacture of Portland cement. At the present time there is one Portland cement plant in operation at Tod inlet, the limestone and clay both being obtained from the adjoining property.

Lime is manufactured on the west shore of Esquimalt harbour, by the Rosebank Lime Co. and by Thomas Atkins. The Silica Brick and Lime Co., situated about a mile west of Esquimalt harbour, on the Esquimalt and Nanaimo railway, manufactures lime, hydrated lime, and sand-lime brick.

SAND AND GRAVEL.

Sand and gravel, for concrete filling and similar purposes, is quarried extensively in the district. The British Columbia Sand and Gravel Co., and the Royal Bay Sand and Gravel Co., operate two banks on the Colwood shore of the Royal roads, the material of the Colwood delta being quarried. The gravel and sand are mined with an hydraulic giant, and then washed and screened. Sand and gravel are also obtained from the esker-like trains to the south of Mt. Tolmie, and from a sand and gravel ridge in northeast Victoria.

CLAY.

The stratified glacial clays are used for common brick and drain-tile at Victoria, Sidney, and Sidney island. At Sidney island the stiff-mud process is used, but at all the other plants the wet-mud process is used for the manufacture of the brick, although at Victoria drain-tile is moulded in an auger machine. No high grade clays are known to occur in the district. The shales of the Nanaimo formation are almost invariably sandy, and are not suitable for other wares than brick and drain-tile.

STONE.

No building stone is quarried at the present time in the area. The older crystalline rocks, even the Saanich granodiorite, are too badly fractured and sheared to yield good building stone. Some of the sandstones of the Nanaimo formation would furnish material of a fair quality, but sandstone of better grade, and more readily quarried, occurs farther to the north and west, and supplies the present demand.

Crushed stone is obtained from the Metchosin volcanics on Albert head by the British Columbia Trap Rock Company. The rock is a somewhat altered basalt of an ophitic or diabasic texture, and furnishes a rock of excellent quality for crushed stone for concrete, road metal, and similar purposes.

TOPOGRAPHIC WORK ON VANCOUVER ISLAND.

(R. H. Chapman.)

Field operations on Vancouver island were begun about the middle of May. One party was organized under K. G. Chipman, and the survey of the Sooke sheet—a rectangle extending between latitudes 48° and 48° 30′ and longitudes 123° 30′ and 124°—was begun.

This sheet includes the full width of the strait of Juan de Fuca, and will show the International Boundary and part of the shore line of the State of Washington.

The same party continued work northward surveying the Duncan sheet, which is bounded by the parallels 48° 30′ and 49° of latitude, and meridians 123° 30′ and 124° of longitude.

Later, a second party under S. A. Wookey was organized, and co-operated in this work.

This sheet shows the eastern shore line of Vancouver island from the head of Finlayson Arm of Saanich inlet to Oyster harbour at Ladysmith, and includes parts of Saltspring and Galiano islands, and the smaller islands of the vicinity.

The field scale of the Sooke and Duncan sheets is 1 to 96000—for publication at about 2 miles to 1 inch; with topography shown by contours at an interval of 100 feet.

About June 1, a party under B. R. McKay was established near Ladysmith, and later a party under T. A. McElhanney; and the surveying of the Nanaimo sheet was begun.

This sheet covers an area bounded by parallels 49° and 49° 15′, and meridians 123° 45′ and 124°. It includes the flat areas of sedimentary rocks, with which the coal of this field occurs, as well as some of the volcanics appearing in the foot-hills. Nanaimo and Northfield and the coast line from Oyster harbour to a point about 10 miles northwest of Nanaimo, are shown, together with the larger (western) part of Gabriola island and the smaller adjacent islands.

This sheet, which joins a portion of the northern edge of the Duncan sheet, was surveyed at a field scale of 1 to 48000, and will be published at about 1 mile to 1 inch. The topography is shown in great detail by contours at 20 foot interval.

All the mapping was prosecuted by the plane-table intersection and traverse methods, essentially the same as used the preceding year. A land area of about 1,000 square miles was mapped.

Very carefully run lines of levels were extended along the Esquimalt and Nanaimo railway, from Langford lake to Ladysmith, thus giving a tie between the datum at Victoria and that at Nanaimo, both of which were used in 1909. Standard bench marks—copper discs or iron pipe—were placed at short intervals on these lines, and were also placed along the lines run during the season of 1909.

This work was done with all the care and precision of the previous work.

Triangulation was extended from stations established in 1909 to points in the vicinity of Buttles and Great Central lakes and Effingham inlet. This work which is available for the extension of the topographic maps, was accomplished with the same refinement as that of the preceding year, and was again done by S. C. McLean.

All the work was greatly retarded by forest fires and smoke, and latterly by heavy and continuous rains.

The field work closed early in December. Efficient service was rendered by the following assistants: F. S. Falconer, R. E. McBeth, K. H. Smith, R. H. Jarvis, F. Bowman, A. U. Meikel and A. G. Haultain.

PARTS OF THE SIMILKAMEEN AND TULAMEEN DISTRICTS.

(Charles Camsell.)

During the season of 1909 geological field work was begun in the Tulameen district on a sheet covering about 160 square miles. About two-thirds of this work was completed in that season, leaving the remaining third to be finished in 1910.

During the season of 1910 nearly two months were spent on the Tulameen sheet itself, and in the examination of such adjacent country as was necessary for the proper interpretation of the geology of that field. The work of compiling the geological data obtained on this sheet in the past two seasons is now in progress, and a final report will be prepared for publication in the immediate future. The essential structural and economic features of this field were outlined in the Summary Report for 1909, so that it will not be necessary here to give more than a mere statement of progress in mining development during the last year.

Besides the work on the Tulameen sheet a few days were spent at Hedley in obtaining information on the development that had taken place there since the completion of the author's report on that district. An examination was also made of certain asbestos deposits situated in the neighbourhood of Okanagan Falls on the east side of Okanagan valley.

A little work was done in the region lying between Tulameen and Nicola valley, and a plane-table and telemeter traverse was carried through along the wagon road between these two points.

The field party consisted of four persons, including J. D. Galloway and W. S. McCann as assistants.

PROGRESS OF MINING IN THE TULAMEEN DISTRICT.

Although most of the ore deposits of the Tulameen district are still in the prospect stage of development, the near approach of the Great Northern railway has within the last year given a slight stimulus to the mining industry, which had previously shown some sign of languishing. Among the various lode metal prospects, such as gold, silver, copper, and platinum, the development has not been great, and in the large majority of cases the work done has only been such assessment duty as is necessary to hold a mineral claim that is not Crown granted.

Placer mining operations received a decided reverse in the early spring, by the washing out for the third time of Lambert and Stewart's dam on Granite creek. Work had advanced so far on this lease that the owners fully expected to be able to mine some 600 feet of the creek bed during the summer. Three seasons had been spent in preparation, and about $10,000 expended on dam and flumes, and it was confidently expected that the gold and platinum obtained from the mining of this ground would have amply repaid them for their outlay.

A few Chinese miners were again placer mining on a part of the bed of the Tulameen river between the mouths of Eagle and Champion creeks. This particular portion of the stream bed has been worked over a great many times since the first

discovery of gold on it. Within the last twelve years it has been mined at least eight times and the old cabins, gravel dumps, and abandoned machinery, show that it had already been worked over years before. Gold and platinum are obtained here in about equal proportions. The evidence suggests that the gold and platinum on the stream bed are replenished annually from some near-by source. What this source is has not yet been determined. There are no prominent gravel deposits directly above this point, but it is significant that it lies immediately below a sheared and broken zone formed in the bed-rock, on the contact of pyroxenite with green schists. The method of working is to divert the water by wing dams to one side of the stream bed, and mine the other by sluicing. The amount of gold and platinum actually recovered was not ascertained, but it appears to have been satisfactory to the miners.

Some placer mining is also carried on annually in Granite creek by a few individuals. Here attention is devoted largely to old channels in the creek valley.

The most important developments in the Tulameen district within the last year have been in coal mining operations. Virtually all the known coal in the Tulameen coal basin has been acquired by the Columbia Coal and Coke Company, and prospecting has been vigorously carried on throughout the year by this Company.

As outlined in the Summary Report for 1909, the rocks of the coal formation are of Oligocene age, and consist of sandstone, shale, conglomerate, and beds of coal. These rest conformably on volcanic rocks, while they are in part overlaid unconformably by a basaltic flow. That the latter is simply a surface flow capping the coal formation has been satisfactorily proved by sufficient evidence. Fissures through which this basalt rose to the surface were noted in two places in the cañon of Granite creek, and it is possible that one or more of these fissures may cut the coal formation itself.

The coal basin is synclinal in structure, with the main axis of the syncline running approximately N 50° W. The total area covered by the Oligocene sedimentary rocks is 3,700 acres. As near as can be estimated by following out the outcrop of the coal seams 3,254 acres of the basin are covered by coal. The lava covers 1,070 acres of the coal-bearing rocks.

Enough work has not yet been done to prove the total number of workable seams existing in the basin, but what work has been done is sufficient to prove that a thickness of 20 feet of coal would be a fair estimate.

Taking the usual estimate of 1000 tons of coal to the acre per foot of seam the basin contains about 65,000,000 tons of coal that can be extracted in mining.

The total thickness of coal as exposed in the workings on Granite creek approximates 50 feet, but a great part of this thickness is made up of narrow seams, separated by partings of clay or sandstone. As the beds are explored some of these partings may pinch out and leave a good workable seam.

Up to the end of August, 1910, over 2,500 feet of tunnelling, drifting, and raising had been done in exploration of the coal basin. Most of this had been carried out at two points—one on Granite creek on the south side of the basin, and the other at Collins gulch. It was found, however, that the outcrop of the coal seams approached nearer to the Tulameen river on Fraser gulch than at any other point in the basin, consequently all recent work has been concentrated there. It is the intention to mine the basin by tunnels driven in at this point. A drill hole is also being sunk through the formation at a point near the head of Fraser gulch. This point was selected on account of its being near the centre of the basin, where a hole would pierce all the strata.

Since returning from the field the important discovery has been made of the occurrence of diamonds in a sample of chromite taken from the perido-

tite of Olivine mountain situated about 7 miles west of Tulameen village. This is the first recorded discovery of diamonds in Canada either in the solid rock or in placer.

As described in the Summary Report for 1909 (page 109) the peridotite forms an elongated body about 2½ miles long and about a mile wide extending from the summit of Olivine mountain northward across the valley of the Tulameen river to Grasshopper ridge. The total area of this body is 2·8 square miles. It is surrounded on all sides by pyroxenite into which it passes by a gradual transition. These two rocks have been thrust through a series of interbedded volcanic rocks, limestones, and argillites, which are believed to be of Triassic age.

The peridotite contains only two constituent minerals, olivine and chromite, and is, therefore, the variety dunite. The chromite in which the diamonds were found is not evenly distributed through the rock mass, but occurs in short irregular vein-like segregations an inch or more in width, in irregular masses, or in small grains disseminated throughout the rock. In all cases it is doubtless a product of differentiation in the molten magma during cooling.

The peridotite in some places is altered to serpentine, but in many places it is quite fresh and shows little evidence of decomposition. It is of the same family of rocks as that to which belong the matrices of the South African and Arkansas diamonds, but it differs slightly from the foreign rock in constituent minerals and in the degree of alteration undergone. The origin of the rock in each instance is identical.

The South African diamonds are found in a decomposed serpentine which occupies circular or elliptical pipes, varying from 20 to 750 yards in diameter. The Arkansas diamonds are found in two isolated bodies of peridotite, the larger of which covers about 60 acres. In Africa, and to a certain extent in Arkansas, the diamonds are distributed fairly uniformly throughout the mass of the rock, so that an estimate can be made of the number of carats that a given area will yield. For example, in South Africa it is estimated that one cubic yard of rock yields about 5 carats, while in Arkansas 16 cubic feet of rock gives 0·21 carats.

Samples of chromite taken from the peridotite of Olivine mountain were submitted to Mr. R. A. A. Johnston, mineralogist of the Survey, to determine the nature of the chromium minerals. In the course of his examination Mr. Johnston secured some insoluble crystals which on subjecting to further tests he found to be diamonds. Platinum and gold were also identified in the residue.

Results previously obtained in the course of a search for the original source of the platinum of the Tulameen district showed that this mineral was often associated with the chromite in appreciable quantity, and Prof. J. F. Kemp in one sample obtained as much as half an ounce to the ton. The sample submitted to Mr. Johnston has yielded platinum at the rate of about one ounce to the ton. When seen under the microscope the platinum appears as small rounded pellets or as thin sheets having a bright metallic lustre. The chromite segregations, however, where they have been observed, are too small and too widely separated throughout the body of the rock to make the extraction of the platinum a profitable commercial venture.

The gold is in considerably less quantity than the platinum.

The diamonds so far obtained by the breaking down of the chromite in the laboratory are of small size, the largest being about the size of an ordinary pin's head. When examined under the microscope many of them are seen to be clear and bright, and apparently of excellent quality. Some have a faint yellowish colour. Other specimens are massive, opaque, and greyish black in colour and are presumably the variety carbonado.

All of the diamonds extracted have been found to be associated with the chromite of the peridotite, and not with the olivine. If this association holds true throughout the mass of the rock the diamonds will be found to be very unevenly

distributed, and for that reason, if for no other, their extraction is a difficult problem. Again, the rock is so fresh and hard that the South African methods of extraction cannot be used here. Mechanical methods cannot for several reasons be advantageously employed, and chemical processes are slow and expensive. The discovery, therefore, of these diamonds in the solid rock of the Tulameen is of great scientific interest even if it does not prove to be of much commercial importance.

Placer deposits have been found in the streams which drain the peridotite, and in these it is to be expected that diamonds comparable in size and quality with those obtained in the laboratory will be found. These deposits may also contain stones of greater size, but in the placer mining for gold and platinum which has been carried on in these streams for a number of years, although stones of commercial size on the sluice boxes should have attracted the attention of miners, the discovery of a diamond has not yet been recorded.

The present discovery of diamonds in Canada is the first that the department has been able to verify. For many years officers of the Survey working in British Columbia have been on the lookout for precious stones, so that the discovery of diamonds has not been altogether unexpected. Some years ago the present Director of the Survey obtained some microscopic crystals which were believed to be diamonds and which gave positive results in all tests to which they could be submitted. At that time he advised the prospectors of British Columbia to be on the lookout for diamonds and expressed the belief that they might occasionally be found in the placers. The present discovery justifies that belief.

A few diamonds have beeen found in the glacial drift in Illinois and Ohio, and as much of the material of this drift has been derived from rocks in Canadian territory and carried southward by glacial action it is presumed that the diamonds also may have had their original source in Canada.

RECENT DEVELOPMENTS AT HEDLEY.

In December, 1909, trains began running regularly into Hedley from the east, over the tracks of the Victoria, Vancouver, and Eastern railway. The effect of this on the mining industry of the Similkameen has been more marked perhaps in other portions of the district than in the immediate vicinity of Hedley. Operations have been carried on more vigorously than formerly on the Sunnyside and Nickel Plate mines, but this is not due solely to the advent of the railway. The Kingston group has been bonded to a Boston company, and exploratory work is being done, but in the remaining part of the camp the exploitation of mineral claims is in virtually the same condition as it was on the completion of our field work there in the spring of 1909.

On August 13, 1909, the Yale Mining Co., owners of the Nickel Plate and Sunnyside mines, sold out to the Exploration Syndicate of New York, who are now operating these mines under the name of the Hedley Gold Mining Company. The Daly Reduction Company also went into the hands of the same people, but the old name is still retained.

Since the change a vigorous policy has been pursued both in the mines and reduction works, resulting in a greatly increased output.

For a detailed description of the geology and ore deposits of this region reference can be made to a recent publication by the present author.[1] For the sake of convenience, however, a brief statement of the geological conditions is here made. The stratified rocks of the district consist of interbedded limestones, argillites, quartzites, and volcanic materials of Palæozoic age, now much altered by igneous intrusion and dynamic action. Into these have been intruded a batholithic mass of granodiorite, and smaller bodies of an igneous complex made up of gabbro, diorite, and

[1] The Geology and Ore Deposits of the Hedley Mining District, Memoir No. 2, Geological Survey Branch, Department of Mines, Canada.

quartz diorite. The ore bodies are of contact metamorphic origin, and are situated on the contact of the altered limestone with apophyses of gabbro which are connected with the main bodies of that rock. The principal ore mineral in them is arsenopyrite, which occurs in a gangue of lime silicate minerals, and yields gold as the chief valuable metal.

At the mines the ore bodies, which a year and a half ago were thought by the former owners to be almost exhausted, have been proved to extend a considerable distance both in length and width. Two new ore bodies have been discovered, one on the Nickel Plate, and another on the Bulldog. A third ore body, lying under the foot-wall of the old Nickle Plate ore body, and formerly thought to consist entirely of low grade ore, has been prospected and found to contain a large quantity of ore, averaging about $12 to the ton.

On the Bulldog claim, which adjoins the Sunnyside on the south, a prospecting adit tunnel has been driven into the mountain at a point about 30 feet below the electric tramway, and not far from Sunnyside No. 1. At the time of examination the tunnel was in about 60 feet, and was largely in ore up to the face. The horizon of this ore body is apparently the same as that of Sunnyside No. 2, and the ore is of somewhat similar character, with perhaps a higher proportion of pyrrhotite to the arsenopyrite. The gangue is largely calcite, with some of the lime silicate minerals.

At Sunnyside No. 2 mine, which has been second only to the Nickel Plate as a producer of ore, the work has been largely stoping of ore, and diamond drilling. Prospecting of this mine has not extended the limits of previously known ore.

On Sunnyside No. 3, which is an incline dipping about 45° on a foot-wall of gabbro, a new level has been opened up, and the main entry driven 120 feet below the first level. On the first level a raise has been put up 112 feet to the north, and is in ore all the way.

Sunnyside No. 4 is also an incline, with a dip of 17° and a length of 420 feet. A drift has been run to the south in the mine and connexion made with Sunnyside No. 3 on the first level. Ore is being stoped from both these mines.

The Nickel Plate mine shows the greatest development. At the last examination, made in June, 1909, only one ore body was being worked in this mine, namely, that lying above the foot-wall of gabbro (andesite). Another ore body was known to lie beneath this foot-wall, but it was always considered to be of lower grade than could be profitably mined at the time.

During our recent examination at the end of July, it was found that the limits of the original ore body had been extended both along and across the strike, and in places about 20 feet of what was originally considered to be the hanging wall has been mined out. The so-called low grade ore body beneath the gabbro foot-wall has been prospected and found to contain some high grade ore, and a considerable quantity—amounting to thousands of tons—of other ore of approximately average grade.

Besides these two ore bodies, a third has been discovered in the lower, or No. 4, tunnel. All three ore bodies are being mined, and at the time of our examination about 18,000 tons of ore had been broken down and was lying in the stopes.

The lower, or No. 4, tunnel, which was originally driven to form the main entry to the mine, and later abandoned, is now being used, and an electric tramway laid into it. Connexion has been made underground from this tunnel to the old workings above, and it is proposed to take all the ore from the mine through this entry. Preparations are also being made to sink from this level.

Besides the developments in the mines there have been improvements in transportation and methods of treatment, resulting in an increase in the quantity of ore milled. Previous to 1910 the reduction works treated a maximum of 135 tons daily. This has been increased to 160 tons, largely by a change in the drop of the stamps

from 6 inches and 106 per minute to 7½ inches and 99 per minute. With other improvements that are now being made it is estimated that the capacity of the mill will shortly be increased to 200 tons per day.

The changes in the mill will include the addition of a 100 ton tube mill for regrinding, Bunker Hill screens for classifying, Deister tables for slime concentration, Merrill precipitating presses to replace the zinc boxes, and Oliver filter presses for dewatering the slime residue.

The power plant also is being improved and increased. All the machinery was formerly operated directly by water-power, but electric motors are now being installed everywhere. A 360 K. W. Westinghouse generator has been installed in the main power house. This is connected at one end of the shaft with a 400 horse-power condensing steam engine, and at the other with a 500 horse-power Doble impulse wheel, so that the plant can be operated either by steam or water-power. By the addition of three new return tubular boilers the steam boiler capacity has been increased from 250 to 700 horse-power.

In spite of all the changes that are being made there has been no interruption of the regular milling operations, and with the increase in the steam boiler capacity there will be no necessity in the future to close down during part of the winter, as was so often done when water was the only motive power. Up to the end of 1908 the total tonnage of ore treated was 153,013. The following table shows the monthly tonnage since that date:—

	1909. Tons.	1910. Tons.
January	....	2,718
February	....	3,052
March	....	1,919
April	1,588	3,921
May	3,831	4,305
June	3,389	4,574
July	3,695	4,549
August	3,873	4,347
September	3,700	4,360
October	3,944	4,300 estimated.
November	3,691	
December	3,392	
	31,103	38,045

Within the last two years the average grade of the ore milled has decreased from $14 per ton to $12 per ton. The extraction has, however, gradually increased, until at the present time it is 93 per cent of the assay value of the ore.

Extraction of gold from the ores of the Nickel Plate and Sunnyside mines began in June, 1904. From that time up to September, 1910, or in a little more than six years, these mines have produced gold to the value of $2,741,277.28.

Since the completion of the field work for the report on the Hedley mining district in September, 1908, some development has taken place in the district, and this development has a bearing on the theory advanced in that report for the origin of the ore bodies. The ores are therein stated to be the result of contact metamorphism, and the theory attributes their origin to the intrusion through beds of limestone of gabbro dykes—locally called andesite—emanating from a main central stock. This intrusion produced the primary ores. Secondary enrichment was also supposed to have taken place in the surface zone by downward moving waters, effecting concentration where dams had been formed by impervious cross-cutting dykes.

Recent development has done much to confirm the theory that the intrusion of the gabbro was the primary cause of ore deposition, and where new ore bodies have been found, they have always proved to be associated with the white gabbro. It is also true, however, that many bodies of gabbro have been intruded into the limestones without forming ore bodies of commercial magnitude.

The theory of secondary enrichment in the surface zone through downward moving waters is not of such general application as the other. While this theory has been found to be true in a few cases, these cases are not in the majority, and one would not be justified in attempting to draw any general conclusions from them. The majority of the ore bodies now being worked do not show any evidence of secondary surface enrichment and appear to contain only the primary ores, which are the result of contact metamorphism. This may be taken as a reason for encouragement to mine owners, for it indicates that secondary enrichment is not necessary for the formation of commercial ore bodies in this camp. It suggests at the same time that ore bodies will be found to persist to depths greater than was first supposed. Both of these factors go to lengthen the probable life of the existing mines, while they tend to increase the probable number of yet undiscovered ore bodies occurring in this camp.

It is true that the average grade of the ore now mined has decreased slightly with the working out of those ore bodies that were near the surface and did show evidence of secondary enrichment, but this decrease has been so slight that there is still a considerable margin of profit in the mining of these ores. The grade of the ore now mined averages about $12, while the cost of extraction is in the neighbourhood of $5 per ton.

The lowering of the grade of the ore with depth has been accompanied by a slight change in its character. The gold now mined is finer and is more intimately mixed with the arsenopyrite, and is not so readily extracted by amalgamation. This change, however, has been met by various changes in the treatment, and so successfully has this been done that a higher percentage of the assay value of the ore is now recovered than was formerly done with the more easily reduced surface ores.

In view of the fact that the surface zone has been passed through, and no great change in treatment has become necessary to meet the change in character of the ore, it is not likely that any radical change, such as the smelting of the ores, will ever have to be resorted to in the future as depth in the mine increases.

THE OCCURRENCE OF ASBESTOS AT OKANAGAN FALLS.

Asbestos is reported to have been discovered at this place in 1898, by G. Maynard, but until the last year nothing had been done to demonstrate its quality, or the area covered by the asbestos bearing rocks. In the spring of 1910, fourteen mineral claims were staked to cover the ground, the owners being Messrs. Ritchie, Hislop, Maynard, and Bailey.

The claims are situated on the east side of Okanagan valley, and on the south side of Shuttleworth creek, which flows into the Okanagan river below Okanagan falls. The claims extend up the slope of the valley, from an elevation of 400 to 2,000 feet above the level of Dog lake.

The sides of the valley slope up gradually but irregularly. The lower part is level land, on which fruit farming is being carried on. The upper parts are rocky, and broken into irregular hills and hollows.

The rocks in which the asbestos occurs belong to the Shuswap series, and this series extends up and down the eastern side of Okanagan valley, and for an unknown distance inland to the east. Patches of Tertiary volcanic rocks are found resting here and there on the rocks of the Shuswap series, and on the west side of the valley they attain a great development.

The rocks of the Shuswap series here consist of granite and diorite gneisses, mica, hornblende, and talc schists, limestones, narrow beds of pyroxenite, and some serpentine. In general the planes of schistosity and gneissic structure are parallel to the planes of stratification in the limestone, the strike being east and west, and the dip at low angles to the north.

The serpentine is the result of an alteration of an impure peridotite, of which a little yet remains in the unaltered state. One, and perhaps two bands are known to occur near the top of the valley slope, but neither of them appear to be as much as 100 feet in width.

The asbestos is found in veins running through the serpentine. These veins vary in width from a fraction of an inch up to 14 inches, and are exposed in a few places by open-cuts to a depth of 4 to 10 feet.

The larger veins appear to show some movement of the walls after the formation of the asbestos, for the middle of the vein shows a break, the fibre not being continuous across the whole width of the vein. The fibre is coarse and sometimes brittle, and though it can be worked up into a soft fluffy mass it lacks toughness and tensile strength, and would not yield either of the higher grades of asbestos product.

The smaller veins, varying in width from ½ to 1 inch, contain a slightly better grade of fibre, but the depth to which they have been exposed is not sufficient to fairly demonstrate the quality.

At present the deposits are handicapped by two things; one is their situation at an elevation of about 2,000 feet above the main Okanagan valley, and the other is the limited quantity of visible serpentine in which asbestos could form. The quality of such fibre as is now exposed is inferior, but it would be unfair to condemn the deposits from this standpoint alone, when so little depth has been attained in development.

SUMMIT CAMP AND VICINITY.

The group of mineral claims locally known as Summit Camp is situated on the divide between Sutter creek on the Tulameen slope and Dewdney creek on the Coquihalla slope. The distance from Tulameen village is about 24 miles, and the camp is connected with that point by a good pack trail running up the Tulameen valley.

Ore was first discovered at Summit Camp in the autumn of 1895, and more or less development of the claims has been done every year since that date. There are now nine surveyed and Crown granted mineral claims, besides fifteen or twenty others on which the annual assessment work is still done.

The country was all burnt over the year after the discovery of ore, and a great deal of valuable fir and spruce timber was destroyed. The elevation of the summit of the divide is estimated by aneroid as about 5,700 feet above sea-level. All of the mineral claims are over 4,000 feet above the sea, and some of the points in the neighbourhood reach an elevation of over 7,500 feet.

The rocks consist of argillites, limestones, quartzites, and breccias, cut through and intruded by igneous rocks of medium basic composition, in the form of dykes and sheets. In lithological characteristics they resemble strongly rocks in other parts of the district, which are classed as of Carboniferous age. They are, as a rule, thin bedded, and dip at high angles, having a general strike about N 20 W. Bordering these rocks on the east is a belt of Cretaceous rocks, but these are of no importance in connexion with metallic ore deposits.

The most pronounced planes of fracture have a strike of about N 80° E. The ore deposits are replacements, generally of limestone, in and along either side of these fracture planes. The ore minerals are galena, zinc blende, chalcopyrite and pyrite, in a gangue of quartz or unreplaced country rock. From the loose appearance of the well-formed quartz crystals in the fissures, and the incipient comb structure exhibited therein, these fissures appear to have been at one time open spaces. Ascending solutions carrying the sulphides have traversed these fissures and deposited the ores in them, at the same time replacing the wall rocks on either side for a distance of 2 or 3 feet. The fissures themselves are narrow and seldom more than 6 inches in width.

The middle portion of the ore body represents the original fissure. This portion is often completely filled with a solid mass of galena, blende, and some copper and iron sulphide. That portion of the deposit which represents the replaced wall rock contains more pyrite, and less galena and blende.

The deposits carry silver as the principal valuable metal, and though not of great size are fairly high grade. A 1,700 pound sample of picked ore was shipped to a smelter a few years ago from one of the claims owned by the Terre Haute Company, and this sample is reported to have yielded 215 ounces in silver, $12 in gold, and 4 per cent in copper. Lack of good transportation facilities has retarded the development of this camp.

During the early spring of 1910, some 20 coal claims were staked out on a belt of Cretaceous rocks lying directly east of Summit Camp, and between the main Tulameen river and its south fork. This belt, at the mouth of Sutter creek, is probably 3 miles wide, and strikes slightly east of south. It is probably continuous with a belt of Cretaceous rocks found on the International Boundary line between Pasayton and Roche rivers, and may also extend northward to connect with other Cretaceous rocks in the valley of the Fraser river.

On the west these rocks rest on the ore bearing rocks of Summit Camp, and on the east on a sheared and gneissic granite which is probably continuous with the Eagle granite of the Tulameen sheet. The basal formation of the Cretaceous on the west is a coarse conglomerate, containing water worn boulders of quartzite and argillite, as well as of plutonic and volcanic igneous rocks. This bed dips at a high angle to the east and rests unconformably on a volcanic andesite.

On the eastern border the basal bed is a volcanic breccia, above which is a hard conglomerate, having a dip of 50° to 70° to the southwest. Above the conglomerate beds on both sides of the belt are massive sandstones, and black, grey, and reddish argillites. The whole basin is clearly synclinal in structure, though it shows minor folds towards its centre.

The sandstones and argillites are cut by dykes of granite, and syenite porphyries and andesite. Faults are of common occurrence.

No coal, either float or in place, was found in this part of the basin. It is, however, quite possible that it may exist, for rock exposures are not very abundant, and the drift is so widespread that the outcrop of a coal seam may easily be covered. It is reported that a thin seam of coal, and some narrow lenses, have been found in this belt farther to the south. Very thin seams of coal undoubtedly have been found in the Roche River district to the south, in rocks which are of the same age and presumably in the same basin as this.

BEAVERDELL DISTRICT, WEST FORK OF KETTLE RIVER, BRITISH COLUMBIA.

(*L. Reinecke*).

The season was spent in finishing the topographic map of the Beaverdell district, which was begun last year. The work was primarily topographic, but attention was given to the geology whenever time could be spared from the topographic work. An area of 162 square miles was mapped on a scale of 4,000 feet to one inch, $\frac{1}{48000}$. The primary and secondary control were obtained by transit triangulation and plane-table intersection, the detail by plane-table and stadia, and plane-table and tape traverse. Work was started on May 25, and the traversemen had all left the field by October 16. After attending to a few details necessary in finishing the topography, we left the field on October 27. Messrs. Chas. C. Galloway, W. G. Hughson, and Karl A. Clark assisted in topography throughout the season. Mr. Ernest Bartlett acted as traverseman up to the end of July, when his place was taken by Mr. F. H. McCullough. Mr. John Stansfield assisted in both topography and geology. My thanks are due these gentlemen for the unfailing interest they showed in their work.

LOCATION.

The area mapped lies in the valley of the West fork of Kettle river, in southern British Columbia. It is included between longitudes 118° 55′ and 119° 10′; and latitudes 49° 25′ and 49° 37·5′. Its southern boundary is 43 miles by wagon road from Midway, on the International Boundary, and almost 23 miles above where the West fork joins the Kettle river. Within the map sheet occur the silver-lead ores of Wallace mountain, the gold-silver ores at Carmi, and the gold and copper prospects of Triple lakes, Knob hill, and Arlington mountain.

HISTORY.

An account of the mining history of the district was given in the Summary Report for 1909.[1]

General Character of District.

TOPOGRAPHY.

A description of the topography was given in the Summary Report for 1909. This description is in the main correct, though the map does not take in as much of the drainage of the main Kettle as was proposed. The completion of triangulation also, has shown the elevation of the higher points within the map to lie between 5,600 and 5,760 feet above sea-level, making the maximum relief within the sheet between 3,200 and 3,300 feet.

A few other facts brought out more clearly by the topographic map may be mentioned here. A series of mature uplands is the most general and striking feature of this part of the Interior Plateau. The main drainage, on the other hand, occupies valleys in which the topography is in a more youthful stage. The present land aspect

[1] On the Beaverdell District, West Fork of Kettle River, B.C., by L. Reinecke. Summary Report of the Geological Survey Branch, Dept. of Mines, Canada, for 1909.

is, therefore, evidently the product of several epochs of erosion. A well marked upland, in which all evidences point to advanced maturity, occurs between the elevations of 4,000 and 4,600 feet. It is well represented in the northeastern part of the map. Above that is another, not quite so well developed, and carved out of what were once extensive volcanic flows. It is thought that at the time the volcanics were laid down on the lower plateau its topography very closely resembled that of to-day.

The valleys show a marked tendency to follow north-south and east-west directions. These are also the more common directions of fault planes in the underlying rocks, and were probably directions of structural weakness in overlying rocks long since eroded away. It may be inferred that the present valleys are the sites of the lines of drainage of the old uplands or plateaus.

The steep sides and flat bottoms of a few of the more important valleys are due to the effects of glacial erosion. Since glacial times the tributary streams, in getting down to the new level of these valleys, have cut gorges near their mouths. These gorges represent the youthful stage of a new epoch of erosion. A further change is recorded in the series of terraces representing old river bottoms left upon the valley sides. They probably represent uplifts since glacial times.

FLORA.

The following plants were collected by Mr. Karl A. Clark in two localities in the Beaverdell district. Both localities are in open valley bottoms, the higher at an elevation of 2,800 feet, and the lower at about 2,500 feet above sea-level. It is hoped that the list may be of interest to those studying the flora of British Columbia. The specimens were identified by Professor John Macoun of the Geological Survey. Popular names are put in parenthesis after the scientific.

1. *Pentstemon confertus,* Dougl. (Beard tongue).
2. *Antennaria parviflora,* T. and G., *var. rosea* (rose-coloured everlasting).
3. *Eriogonum heracleoides,* Nutt.
4. *Pyrola asarifolia,* Hook. (Liverleaf wintergreen).
5. *Erigeron speciosus,* DC. (Large flowered fleabane).
6. *Geum triflorum,* Pursh.
7. *Campanula rotundifolia,* L. (Scotch harebell or bluebell).
8. *Achillœa millefolium,* L. (Yarrow).
9. *Senecio balsamitœ,* T. and G., (Balsam groundsell).
10. *Lupinus laxiflorus,* Dougl. (Loose flowered lupine).
11. *Galium boreale,* L. (Northern bedstraw).
12. *Spirœa betulifolia = glauca,* Green.
13. *Astragalus campestris,* Gray. (Prairie milk vetch).
14. *Epilobium angustifolium,* L. (Willow herb).
15. *Zygadenus elegans,* Pursh.

General Geology.

TABLE OF FORMATIONS.

Quaternary..	River deposits, glacial till.
Miocene..	Basalt, andesite, and dacite lavas.
Oligocene (?)..	Volcanic breccias and tuffs.
Jurassic (?)..	Granodiorite batholiths.
Pre-Jurassic...	Limestones, argillites, cherts, with interbedded volcanic matter and intruded dykes.

PRE-JURASSIC.

A series of limestones, jasperoids, and argillites occur in patches or narrow strips within granodiorite, in the southeastern part of the district. They are accompanied by interbedded volcanic matter, and intrusive aplite, augite-porphyrite, quartz porphyry, and younger feldspathic dykes. The sediments are all intensely metamorphosed, and almost all traces of bedding have disappeared. The interbedded volcanic matter appears to be of nearly the same age as the argillite or hornfels with which it is associated. The intruded dykes are of much later age. The mode of occurrence of the sediments, and the relations at the contacts with the granodiorite, indicate that they are older than the latter. It has been suggested that they are remnants of a sedimentary roof at one time covering the batholith. No fossils were found in them. They resemble strata found in the Boundary district, which have been provisionally classed as Palæozoic.

JURASSIC.

Most of the area examined up to an elevation of about 4,500 feet is underlain by granodiorite. Four types were recognized in the field. They vary in composition from a basic diorite to a rock closely resembling the Nelson granite, and represent several distinct intrusions.

TERTIARY.

Volcanic rocks of Tertiary age occupy the higher points. They consist of breccias and tuffs, overlain by dacites, andesites, and basalts. The breccias and tuffs are found in the region around Goat mountain, in the south. They have been assigned to the Oligocene through their resemblance to tuffs of that age in the Boundary district. No shales or sandstones were found with them.

Dacites, andesites, and basalts overlie the tuffs at Goat mountain, cap the high hills around the Nipple, and are found in patches in the northeastern half of the sheet. They are classed as Miocene.

RECENT.

Recent deposits consist of glacial till, talus, and river deposits. A thin mantle of glacial drift is found over most of the uplands. The river deposits, consisting partly of resorted glacial materials, are found in the form of terraces on the valley sides. There are series of them in some places ranging in elevation from 10 to over 100 feet above the present stream bed.

Economic Geology.

An account of the silver-lead ores on Wallace mountain, and the gold-silver ores at Carmi, is given in the Summary Report for 1909[1]. The Sally mines, on Wallace mountain, were shut down last winter, and very little mining has been done since. A railway is now, however, being built from Midway through Beaverdell. This will eliminate the long and expensive hauling of ore by wagon to Midway, which has been one of the chief hindrances to the opening up of the district. Renewed activity may be expected in the Wallace Mountain camp on its completion.

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[1] On the Beaverdell District, West Fork of Kettle river, B.C., by L. Reinecke. Summary Report of the Geological Survey Branch, Dept. of Mines, Canada, for 1909.

SLOCAN DISTRICT, BRITISH COLUMBIA.

(O. E. LeRoy.)

The Slocan geological map sheet comprises an area of about 260 square miles, in the mining divisions of Ainsworth and Slocan, British Columbia. It includes all the mining centres from Fourmile on the south to Whitewater basin on the north; the east and west boundaries are Kootenay and Slocan lakes respectively. The field work, which is now completed, occupied the greater part of two seasons, during which period the writer was assisted most efficiently by Mr. C. W. Drysdale. Messrs. S. A. Hutchinson and R. Bartlett were appointed to the field staff of 1910, and both rendered material aid. The hearty co-operation of the mine owners and superintendents was of great assistance in facilitating the work connected with the examination of the mines.

During the midsummer of 1910 a portion of the district was visited by a most disastrous and fatal fire, in which six lives were lost and a large amount of valuable property wes destroyed. The Kaslo and Sandon railway was completely crippled as far east as Sproules. An irregular service has been kept up between Sproules and Kaslo, but this will be discontinued through the winter. It is to be hoped that the policy of the Great Northern Company will be to repair and rebuild the road at an early date. In the meantime a wagon road, built from Three Forks on the Canadian Pacific railway to Whitewater and to the Rambler Cariboo mine, is being utilized. The Canadian Pacific railway, only temporarily affected by the fire, operates a line from Sandon to Roseberry, where connexion is made with the lake service to Slocan city.

TOPOGRAPHY.

The Slocan district lies within the Selkirk system, which is here composed of a series of rugged ridges without any general trend. The crests are usually sharp, the general altitude varying from 6,000 to 8,000 feet above sea-level. The slopes are either bare, or covered by a mantle of wash or glacial drift of varying thickness.

A marked feature of the district is the transverse valley which extends from Kaslo to New Denver, with a low divide at Bear and Fish lakes, separating the drainage systems of Kaslo creek and Seaton-Carpenter creeks, which flow into Kootenay and Slocan lakes respectively. Schroeder creek, flowing into Kootenay lake, and Wilson and Fourmile flowing into Slocan lake are other important streams. The tributaries of all the main streams flow with steep gradients, with many local falls and cascades, and either enter the main valley at grade, or by a series of small falls through narrow gorges.

Water-power has been developed at several points to suit local requirements for mines and towns. Of the undeveloped powers the most important are the falls on Wilson creek.

GENERAL GEOLOGY.

The rock series underlying this district are the Shuswap, Selkirk, and Slocan, of which the former is Pre-Cambrian. The relative ages of the Selkirk and Slocan series have not yet been fixed with any degree of definiteness, owing to the apparently entire absence of fossils. The present contact relations between the three above series is to be accounted for by intense folding, accompanied by overthrust faulting

during the later epochs of mountain building. The biotite schists of the Shuswap are in sharp contact with the softer green schists of the Selkirk, and those of the latter are similarly related to the black slates of the Slocan series.

Near the border of the Selkirk small infolds of the Slocan series are occasionally to be found, while along the Blue ridge summit there is a marked syncline, passing southwards into a monoclinal fold, the central portion of which is composed of rocks lithologically identical with those of the Slocan series.

In Jurassic, or post-Jurassic time the above series were intruded by enormous batholiths of granitic rocks, and mountain building processes continued long after this intrusion, as evidenced by the folded and faulted dykes and sills genetically connected with the batholith.

The Tertiary period is not represented in this district, and the Quaternary only by limited areas of glacial drift and alluvium.

Shuswap Series.—The Shuswap series is developed as a comparatively narrow band along the west shore of Kootenay lake, broadening somewhat in its northern extension beyond Schroeder creek. The series consists of interbedded acid and basic gneisses, hornblende, and biotite schists, quartzites and crystalline limestones, with intercalated sills of granite, quartz porphyry, diorite, etc. The general strike makes a slight angle with the trend of the shore line, and varies from N 15° W to N 25° W, with southwest dips ranging from 45° to 85°. The series also occurs along the east shore of Kootenay lake, and the west shore of Slocan lake in isolated exposures.

Selkirk Series.—The Selkirk series occupies a roughly triangular area in the north and northeast part of the sheet, and is composed, in the main, of rocks of igneous origin, with but a small development of sedimentaries. Hornblende, chlorite, and quartz schists predominate, with subordinate breccias, partially sheared eruptives both acid and basic, silicified ash rocks, cherts, quartzites, and limestones. Of the basic eruptives, dykes and masses of serpentine are of most frequent occurrence. The general strike of the series corresponds with that of the Shuswap, and in the northern extension of the series gradually swings to the west. With the exception of a portion of the Blue ridge syncline, the dips are prevailingly to the southwest and south.

Slocan Series.—This series occupies the main area of the sheet south and west of the Selkirk. It is composed of interbedded sandstones (passing into quartzites), argillites, slates, and limestones, with all grades of transition between the main types. The slates are usually highly carbonaceous, and in a crushed form become graphitic. The quartzites and sandstones are usually impure from clayey and calcareous material, and the limestones are both carbonaceous and argillaceous.

In the zone of contact metamorphism surrounding the granodiorite batholith, the above rock types have been altered to andalusite, biotite, and quartz schists, hornstone, crystalline limestone, and marble.

The series lies in an irregular basin, the rocks overlying the Selkirk on the east margin, and apparently the Shuswap on the west, although the Selkirk may also be present but concealed by the waters of Slocan lake. No basal beds are exposed, but sandstones and quartzites are predominant in the west, while limestone is a more prominent member of the eastern portion of the series. In the west the strike of the rocks is northerly, in the main, but gradually swings to the east and south of east, roughly corresponding to the trend of the contact between the Slocan and Selkirk series. The dips are usually high, and are rarely under 40°.

IGNEOUS ROCKS.

With the exception of those rocks peculiarly associated with the Shuswap and Selkirk series, the igneous rocks are later than the Slocan series. The oldest group

occurs chiefly as sills in the slates and quartzites; they are completely altered and now consist of secondary quartz, carbonates, mica, and chlorite.

To Jurassic or post-Jurassic time is referred the enormous batholithic intrusions of granodiorite and other closely related plutonic rocks which occupy so large an area in the West Kootenay district. The northern part of the Nelson batholith occupies the greater portion of the southern border of the Slocan sheet. The rock varies from mica and hornblende granites to granodiorites, and even more basic types. They range from medium to coarsely porphyritic in texture, and in colour from light grey to almost white. Genetically connected with this batholith is the great series of sills, dykes, bosses, and stocks of finer grained porphyritic varieties of the above plutonics, which are widespread throughout the area, with the greatest development in the rocks of the Slocan series.

At a somewhat later period all the older rocks, both sedimentary and igneous, were cut by basic, mica lamprophyre dykes, and these represent the last evidences of igneous activity in the district.

Economic Geology.

Silver-lead and zinc deposits occur in the granitic rocks of the Nelson batholith, and in the Selkirk and Slocan series, the most important and numerous ore bodies being found in the Slocan slates.

In the Selkirk the ore bodies occur in the greenstones and schists, and have been found hitherto to be too small and of too pockety a character to render them important products. In the granitic rocks the ore bodies occupy fissures or zones of fissuring, which may correspond to the local master jointing in the rock. The fissure may be several hundred feet long, with a width varying from that of a knife blade to 5 or 6 feet. Both wet and dry ores occur in the granite; examples of the former are the Fisher-Maiden, Mountain Con, and Flint mines; and of the latter the Molly Hughes, McAllister, Sweetgrass, etc. In the rocks of the Slocan series the fissure system is best developed and contains the largest veins and ore bodies. The veins vary in length from a few hundred to about 4,000 feet, and in width from a few inches to 50 feet. They almost invariably cut across the strike or dip of the formation, bedded veins being quite rare. In such a wide area the strike varies greatly, and the dips range from 30° to 80°. The veins either end by swinging in on the bedding plane of the slates and quartzites, or feather out in the broad bands of softer slates. Faulting is difficult to detect on account of the similarity of the rocks; it is only where sills of porphyry occur that the small displacements may be seen.

Where the vein is wide the filling is largely crushed and broken country rock. Siderite, quartz, and calcite are the most common of the gangue minerals, and the deposits are characterized by having one of the above either as the predominant or as the almost exclusive gangue mineral.

The ore shoots are usually composite in character, and consist of irregular bands, lenses, and masses of clean galena or zinc blende, and intimate mixtures of the two.

The shoots vary from a few feet to 400 feet or more in length, and from a few inches to 40 feet in width. As a rule, the pay streaks of high grade ore favour the hanging wall, and vary from a fraction of an inch to over 5 feet in width.

The ore bodies favour the softer slates and sandstones which are more carbonaceous, rather than the quartzites and porphyries, but there are some exceptions in which the reverse is true.

The ores are classified under wet and dry; the former having calcite or siderite as gangue with the galena, while the latter have quartz. Galena, and blende, with tetrahedrite (freibergite, grey copper), are the chief metallic minerals. Ruby and native silver, and argentite are found in a few deposits. Chalcopyrite and pyrite are almost invariably present, the former in small amount, and the latter in increasing quantity as the lead content decreases.

At present the values of the ores mined range from about 7 per cent lead, and 20 ounces of silver, to the ton—which is low grade concentrating ore—to the high grade ore which ranges from 50 per cent to 75 per cent lead, and from 80 to 175 ounces of silver per ton. The dry ores run high in silver, with low lead content. Gold occurs in many of the ores, with assay values from $1 to $7 per ton.

MINING.

The following is a list of the producing properties of 1910:—

Whitewater, including the Deep, Rambler-Cariboo, Lucky Jim, Hope, Richmond, Eureka, Slocan Star, Van Roi, Standard, Hewitt, Bismark, Flint, Emerald, Utica, Ohio, Panama, McAllister, Payne, Evening, Bachelor, Idaho-Alamo, California, Molly Hughes, Noonday, Buffalo, and Fisher Maiden. The amounts produced by the above individual mines range from half a ton to about 4,000 tons. Steady development has been carried out on the Washington, Noble Five, Surprise, Twilight, and Sunset, with minor work on the Twilight, Jackson, Rio, Winona, Charleston, Sure Thing, Jo Jo, Milton, Monte Cristo, Sweet Grass, Elkhorn, Ya Ya, and several other properties.

Whitewater.—The Whitewater includes the Deep property, as both are on the same vein, and are operated under one management. The destruction of the mill and village by fire in July caused a temporary cessation of mining operations. During 1909 a cross-cut tunnel was driven to the vein from the valley of Kaslo creek, which gives a vertical depth of about 1,400 feet below the apex of the vein, and about 400 feet below the Deep or lowest drift tunnel. The upraise to connect with the present workings will be completed this winter, and at the same time intermediate levels and cross-cuts will be driven to prospect the vein between the main cross-cut and Deep tunnels. This is the most important development work recently undertaken in the Slocan district, and the results obtained will have a marked influence on further developments of similar character elsewhere in the district.

Lucky Jim.—This mine is the only one worked almost exclusively for zinc in the district. During the year of 1909 about 4,700 tons were shipped, with zinc content ranging from 39 per cent to 54 per cent. In 1910 No. 5 tunnel has been driven 200 feet vertically below the old workings, and has encountered two ore bodies, the size and character of which has not yet been definitely ascertained. No. 6 cross-cut is now being driven some 400 feet vertically below 5. The work this season was greatly hampered by the fire which destroyed all the buildings.

Rambler-Cariboo.—Mining was seriously interrupted by the fire which destroyed the buildings in July, and the mine was only put on a working basis again in the early part of November. The ore body discovered in 1909 has been partially developed on the eighth and ninth levels, with very encouraging results. The shoot pitches to the south, and all the lower levels will be driven in that direction during the winter and the ground thoroughly explored. The development work is sufficiently advanced to permit immediate and extensive stoping. The clean lead ore carries up to 64 per cent lead, and 175 ounces of silver per ton.

Hope.—The Hope mine, situated at Sandon, is still in the development stage, and the ore so far stoped has come mainly from drifts and raises. Four drift tunnels have been driven on the vein, and a fifth has been started. The most productive portion of the vein lies in the eastern half of the mine, between the second and fourth levels. There the ore body is made up of a series of lenses, the whole pitching rather flatly to the east or out of the hill. The ore is high grade throughout, from the large admixture of grey copper in the lead and zinc. With the completion of the lowest tunnel and the necessary raises to No. 4, the mine will be in a position to make steady and large shipments.

Richmond-Eureka.—This mine, owned and operated by the Consolidated Mining and Smelting Company of Canada, is situated at Sandon, on the opposite side of the gulch from the Slocan Star, the vein being the eastern extension of the Star vein. Up to June 30, 1910, the mine has produced and shipped 7,958 tons of ore, containing 443,938 ounces of silver, and 2,848,743 pounds of lead, the gross value being $334,648. The lowest, or No. 6, is a joint tunnel with the Slocan Star, as at this level the vein traverses the ground of both companies. The main work of the latter Company in recent months has been to develop the extension of the Richmond vein, both on No. 6 level and through the Slocan King tunnel.

Standard.—The Standard is situated on Fourmile, above Silverton. The large ore body developed on the lower levels has been the most important feature of mining development during 1910. The ore body is the continuation of that stoped on the level of No. 1 tunnel, and has steadily improved with depth, both in size and values. On No. 4 it is about 320 feet long, with clean ore varying in width from a few inches to 9 feet. On No. 5, when the drift was about 100 feet in the ore shoot, the vein had widened to 30 feet, with 23½ feet of ore, at one point over 12 feet being clean galena. The present shipments come only from development, the clean ore carrying from 70 per cent to 73 per cent lead, and from 80 to 90 ounces of silver to the ton.

No. 6 tunnel is now being driven, but is not in far enough to catch the ore body on its pitch. This level is 573 feet below No. 1.

Van-Roi.—The Van-Roi mine is situated on the south side of Fourmile, and just east of Granite creek. There are at least two veins on the property, and both are being developed at present. They are not quite parallel, but approach each other in their eastward extensions. They are known as the main or north, and the Beryl or south veins respectively, and have been partially developed by nine tunnels covering a vertical range of about 1,000 feet. In the past the ore was mainly won from the large ore bodies in the main vein, but recent developments are proving the existence of a large shoot in the south vein, which in future will probably produce the greater bulk of ore. Only development work is being done at present, and stoping will not be started until the new mill at the junction of Fourmile and Granite creeks is completed. An aerial tram-line now being installed connects No. 5 level with the mill.

Up to the end of 1910 the total production has been 78,203 tons. The ore is of the dry type, is low grade in the main, with lenses of high grade ore, and is characterized by having, as a rule, considerable ruby silver. The average of the metallic content of the ore for June, 1910, was 18 ounces of silver, 7·75 per cent lead, and 12 per cent zinc.

Hewitt.—The Hewitt joins the Van-Roi group to the west, and is on the same zone of fissuring. The mine buildings have been transferred to the east side of the ridge across which the vein outcrops, and the mine is connected with the Wakefield mill by an aerial tram. On the east side of the ridge the vein system is developed by seven drift tunnels. During the past two years development only has been carried on, and ore shipped has come from such work. The vein system on the second and third levels consists of the north, main, south, and main south veins. The two former join to the east, and the main is connected with the main south by the south vein. The largest ore bodies occur in the north and main veins, continuing down to and below the sixth level on the north vein. East of the main ore bodies, there are in the north vein smaller shoots of high grade, containing ruby and native silver, with considerable grey copper.

The Washington, Surprise, Noble Five, and Sunset have been engaged in development work only, and have made no shipments during the past year.

The Washington-Slocan Boy vein has been opened up by four main tunnels, with some intermediates. No. 1 is being driven through the hill in order to prospect the

ground for bodies of clean lead, or high grade ore. Below No. 1 an important body of zinc blende, containing some lead, is being blocked out on and between the several levels.

The Surprise raise has been driven almost continuously since the autumn of 1909, and it is expected that connexions will be made with the old workings in Surprise basin some time early in 1911. With the raise completed active prospecting of the vein will be commenced.

On the Noble Five, the Deadman vein has been opened up by four drift tunnels and the ore body has been partially blocked out. Work on the Noble Five vein will be extended during the winter. A certain amount of ore has been taken out during the past year, but none has been shipped.

The Sunset is still driving No. 8, or the lowest tunnel, but with changed course, to bring the level directly under the projection of the ore body which extends downward from the seventh level.

Of the properties at present idle the more important are the Payne, Queen Bess (Queen Dominion), Reco, Alamo, and Bosun. All of them contain blocks of ground which should, in the light of past experience, prove favourable for ore bodies. With the exception of the Payne, which would require a lower adit level 600 or 700 feet below No. 5, the other properties have sufficient levels already driven, and the ground could be immediately prospected by upraises, with intermediate drifts and cross-cuts.

Such development as indicated would, of course, necessitate a varying amount of initial capital, and in the case of a lease, the owners ought to allow most liberal terms, and depend mainly on the benefits resulting from the proper development of their properties.

Deadwood Camp, Boundary District.

A small area in the Deadwood camp, consisting of about one-half of a square mile, was geologically mapped on the scale of 400 feet to 1 inch. It includes the Mother Lode, Crown Silver, Sunset, and Marguerite mines, and the map will be similar in character to those previously made of the Rossland and Phœnix camps. The areal geology was in charge of Mr. C. W. Drysdale, while the writer devoted his time to a study of the ore bodies and associated rocks. The area will be the subject of a special report which is now in course of preparation.

Franklyn Camp.

A week was spent in the Franklyn camp, on the north fork of the Kettle river, and a general examination of the geology and ore deposits was made, sufficient data being collected to outline detailed work for another season.

TOPOGRAPHICAL WORK IN THE SLOCAN AND DEADWOOD DISTRICTS.

(*W. H. Boyd.*)

The mapping of the Slocan district, begun last year (1909), was continued during the past season (1910). The methods employed were the same as those used the previous year, namely: camera, plane-table and stadia, compass and telemeter.

It was intended to complete the Slocan work this year, but, unfortunately, the dense mantle of smoke that hung over the country generally, and particularly over the Slocan district—due to the prevalence of forest fires—almost entirely prohibited camera station work from the middle of July to about the end of September; hence, it was impossible to obtain the information necessary for the complete mapping of the area.

One very disastrous fire swept over part of the area embraced by the map sheet, resulting in the loss of human life; the destruction of mining and railway property; the burning of much valuable timber, and the complete wiping out of the small town of Whitewater.

During the latter part of July and all of August, the time was occupied in obtaining as much information as possible by running traverses. Some camera stations were occupied during this period.

On August 29, the party moved to the Deadwood district, where a detail map of the vicinity of the Mother Lode and Sunset mines was made on a scale of 400 feet to 1 inch, with contour lines at 20 foot intervals. This map was completed by the end of September, as the smoke did not interfere with instrument work on this particular scale. The area embraced by the map is about one-half a square mile, and includes the Mother Lode, Sunset, and Marguerite mines. The method employed was: transit and stadia control traverses, cutting the area into small blocks; the detail being put in from the control hubs by plane-table and stadia.

On September 19, accompanied by Mr. Sheppard and one assistant, I went back to the Slocan district, in order to determine if it were possible to secure enough camera stations to complete the mapping. The remainder of the party was left, under Mr. Lawson's superintendence, to complete the Deadwood work. After arrival in the Slocan, rain fell almost continuously, consequently, while some results were obtained, it was found impossible to finish the work; the rain continuing nearly every day, with an ever increasing amount of snow on the higher levels, rendered station work prohibitory.

On October 3, the field season closed. Leaving the Slocan, I joined the Director at Nelson, and accompanied him to Frank, Alta., where a day was spent on Turtle mountain, after which I left for the east.

Messrs. W. E. Lawson and A. C. T. Sheppard were attached to the party as topograhical assistants, and both rendered efficient service. Messrs. E. E. Freeland, J. R. Cox, D. B. Cole, and H. F. Collier, were appointed as field assistants and did their work in a satisfactory manner.

On the way west, early in the summer, a few days were spent with Mr. W. A. Johnston, in connexion with the mapping of the area in the vicinity of Barrie, Ont. During the last week of July a visit was made to Mr. Reinecke's camp on the West fork of Kettle river; for the purpose of looking over the area included in the map sheet on which he was engaged, to see the progress of the work, and to inspect the methods used. A similar visit was made during the latter half of August to the parties working on Vancouver island, under the supervision of Mr. R. H. Chapman.

RECONNAISSANCE IN EAST KOOTENAY, CRANBROOK SHEET.

(Stuart J. Schofield.)

The season of 1909 was spent in completing the geological and topographical mapping of the Cranbrook sheet, an area in southeastern British Columbia enclosed by 115° 45′ and 116° 30′ west longitude, and 49° 30′ and 49° 45′ north latitude, embracing an area of about 575 square miles. A base line 1¾ miles long was measured on the St. Mary prairie and expanded into the main triangulation of the sheet. A trip was made to the International Boundary line for the purposes of correlation with geographical formations recognized in the Boundary survey. The writer was ably assisted in the field work by Messrs. L. E. Wright and R. Bartlett. The field season lasted from June 5 to November 17. The rocks and some of the prospects occurring in the area were described in the Summary Report of 1909.

SUMMARY AND CONCLUSIONS.

The region is underlain by a very thick, conformable sedimentary series, which is Cambrian or Pre-Cambrian in age. It is intruded by numerous sills of variable composition and small cross-cutting bodies of granite and granite porphyry. The principal ore-deposits of the area occur in the Kitchener formation, and are probably associated with the Purcell sills and the granite intrusives. The proper exploitation of the numerous copper deposits, which are low grade in character, will require economical management, and the bonding together of a large number of claims, in addition to good transportation facilities. The silver lead ores are now mined at the Sullivan mine, and successfully treated at the Consolidated Mining and Smelting Co.'s smelter at Trail.

The structure of the region is anticlinal, caused by mountain-building forces acting in post-Jurassic times.

GENERAL GEOLOGY.

The division of the sedimentary series into the three subdivisions, Creston, Kitchener, and Moyie, is based solely on lithological characters and structural relations; fossils were diligently sought for at all horizons, but without success.

TABLE OF FORMATIONS.

Pleistocene and Recent	Unconsolidated gravels and sands.
Jurassic ?	Dyke intrusions; aplite, quartz porphyry, and pegmatite.
	Granite; hornblende granite, granite porphyry.
Cambrian ?	Moyie formation; argillites, argillaceous quartzites, limestones, quartzites.
	Dyke intrusions; lamprophyrs.
	Purcell sill intrusions; sills probably of three types:—
	(1) basic: abnormal gabbro.
	(2) acid: abnormal granite.
	(3) differentiated: abnormal gabbro phase at bottom gradually passing into granite at the top.
	Kitchener formation; argillaceous quartzites, quartzites, argillites, limestone.
	Creston formation; argillaceous quartzites, quartzites, argillites, limestone.

Creston Formation.—In the western part of the area this formation consists of well-bedded quartzites and argillaceous quartzites, the beds having average thicknesses of 1 foot, separated by very thin beds of argillite. These sediments are a light grey colour on fresh fracture, and weather in grey tones. Ripple marks are present at various horizons. In the eastern part of the area, the formation becomes thinner bedded and more argillaceous; occasionally small bands of limestone occur. The estimated thickness of the formation is about 7,500 feet.

Kitchener Formation.—This formation consists of an alternating series of heavy bedded and thin bedded argillaceous quartzites and purer quartzites, the average thicknesses of which are 1 foot and 3 inches respectively. On fresh fracture, the sediments are generally a very dark grey to black. The heavier beds weather in grey tones, while the thinner beds weather a reddish brown, and, being in greater amount, give the prevailing red colour to the formation as a whole. One bed of grey limestone was found near Marysville. The estimated thickness of this formation is over 6,000 feet.

Purcell Sills.—The greater number of the Purcell sills were injected into the Kitchener formation. They were intruded probably near the close of the Kitchener epoch and before the Moyie, as no sills were found in the Moyie formation. Differentiation is well shown in some of these sills. At the bottom of each differentiated body is a gabbro phase, passing gradually into a granite at the top. The contact effect of these intrusives on the sediments is very slight.

Dyke intrusion; small, fine-grained, lamprophyric dykes are associated with the above-mentioned sills.

Moyie Formation.—This formation lies conformably upon the Kitchener formation. It is composed largely of very thin-bedded argillites, with a subordinate amount of pure quartzites and argillaceous quartzites. Near the middle of the formation limestone having a thickness of 150 feet is exposed on Whitefish creek. It is white in colour and weathers buff. Worm trails and borings were found near the base of the formation. The estimated thickness of this formation is over 10,000 feet.

Granite Intrusion.—Numerous small cross-cutting bodies of hornblende granite and granite porphyry, from 200 feet to 2 miles in diameter, cut all the sedimentary formations. They are relatively small in size, and seem to be associated with the major faulting in the region. No relation exists between this granite and the granite of the Purcell sills.

Dyke Intrusions.—Dykes of aplite, quartz porphyry, and pegmatite cut the younger granite and occur as apophyses in the sediments.

Pleistocene Deposits.—At the head of Palmer Bar creek, typical morainal material occurs, while over the whole region numerous sub-angular boulders of granite and diorite were found. Glacio-fluviatile gravels and sands are present in all the valley bottoms, and form benches on both sides of the valley.

Economic Geology.

The economic deposits of the region may be classified as follows:—

Metalliferous:—
- Silver-lead deposits,
- Copper deposits,
- Gold-quartz veins,
- Placer deposits.

Non-metallic:—
- Shale,
- Limestone,
- Marble,
- Clay.

SILVER-LEAD DEPOSITS.

The Sullivan Mining Group.—The Sullivan mine, situated about 2 miles north of Kimberley, resumed operations in January, 1910, under the management of the Consolidated Mining and Smelting Company of Canada which has a lease of the property until January 1, 1911. Prospecting of the ore body is being pursued on an extensive scale. The deposit occurs near the top of the Kitchener formation, and is a replacement of argillaceous quartzites by a fine-grained mixture of galena, zinc blende, and pyrite. The gangue, which is small in amount, consists of garnet and pyroxene intimately associated with the ore. During the first half of 1910, 6,704 tons were shipped to Trail, which yielded 46,196 ounces of silver, and 2,451,758 pounds of lead.

Mascot and Eclipse.—These claims are situated on the east branch of Hells Roaring creek, at an elevation of 5,800 feet. The vein occurs in the argillaceous quartzites of the Creston formation; it is well defined and conforms in dip and strike with the sediments, which near the vein dip N 5° E, angle 69°. The ore, consisting of galena, with a small amount of chalcopyrite in a quartz gangue, favours the hanging wall, and is associated with a band of gouge about 1 foot wide. At the bottom of a shaft 56 feet deep, which opens up the deposit, the vein is somewhat broken, but is still in evidence. About 200 feet down the hill from the outcrop of the vein, the sediments are intruded by a granite porphyry which contains large idiomorphic crystals of orthoclase in an isometric ground-mass of plagioclase, quartz, and hornblende. The following assays were supplied by the owners, Messrs. Tarrant and Angus:—

Sample.	Gold.	Silver.	Lead.	Copper.
	Ozs.	Ozs.	%	%
1	0·04	2·2	10·3	
2	0·16	0·6		
3	0·10	6·1	57·8	
4	0·24	3·4	....	1·2
5	0·11	6·8	49·4	
6	2·00	4·17	39·50	
7 (Dump)	4·80	2·34	....	4·12
8	2·20	4·69	32·11	

COPPER DEPOSITS.

The copper deposits occur as veins cutting the Purcell sills and also as impregnations or differentiations in the sills. The veins usually occupy zones of shear, their strike varies greatly in direction, and the dip is high in most cases approaching the vertical. In one or two cases, veins containing copper, with a little galena, were found at the contact of the sills with the quartzites. In one case, a vein which was very strongly defined, and about 8 feet wide in the sill, quickly pinched out in the neighbouring quartzites. The sills in which these veins occur vary from 6 feet to 2,000 feet in thickness.

McKay's Claims.—These are situated on the northern slope of Whitefish creek, and about 7 miles from where it joins St. Mary river. The vein, which is 8 feet wide, occupies a shear-zone in a Purcell sill of basic type. The ore consists of chalcopyrite and cupriferous pyrite in a quartz gangue. Sheared fragments of the wall rock occur in the vein, and along the wall of the vein the feldspars show an alignment parallel with the vein.

Sylvia.—This claim is situated about 2 miles east of Marysville, and contains a vein 7 feet wide in a coarse-grained abnormal gabbro which probably forms one of the Purcell sills. The vein contains cupriferous pyrite in a gangue of quartz and calcite.

Blue Dragon.—The Blue Dragon claim is situated about 1 mile east of the Sylvia. The vein, consisting of a number of vertical shear-zones, contains 4½ feet of workable ore, which consists of chalcopyrite and pyrite in a quartz-calcite gangue. An open-cut 20 feet long and 7 feet deep exposes the deposit.

Black Hills.—This claim, adjoining the Dragon, contains three main veins, probably in a Purcell sill of basic type. An open-cut exposed two intersecting veins which are 6 to 8 feet in width, and are filled with quartz impregnated with pyrite and cupriferous pyrite.

Yankee Girl.—This property contains a quartz vein 6 feet wide which carries pyrite and chalcopyrite as ore minerals. Cobalt bloom occurs as one of the products of oxidation. A shaft 25 feet deep, and an open-cut expose the vein. The following assays were supplied by Messrs. Angus and Tarrant:—

Sample.	Gold.	Silver.	Copper.
	Ozs.	Ozs.	%
1 (open-cut)	0·80	1·44	6·90
2 " "	0·44	4·20	2·05
3 (shaft)	trace	2·80	3·50

Cole's Claim in the Bootleg Basin.—The vein, which is 4 to 5 feet in width, occurs in a Purcell sill of basic type. It is a shear-zone filled with quartz containing some cupriferous pyrite. A tunnel 350 feet in length, at an elevation of about 7,200 feet, has been driven along the strike of the vein.

Evans Group.—Work is being pursued on these claims to determine the size of the low grade ore body.[1]

Omineca.—This claim is situated about 1 mile west of Marysville, at an elevation of 3,100 feet. The vein occurs probably in a Purcell sill. It is 7 to 8 feet wide, and contains chalcopyrite and pyrite in a quartz-calcite gangue. An inclined shaft has been sunk on the vein to the depth of 60 feet.

GOLD-QUARTZ VEINS.

A number of quartz veins occur in the argillaceous quartzites of the Creston formation on Perry creek, but only one group of claims is at present being worked.

Running Wolf.—This claim is owned by the Perry Creek Mining Company, and is situated on French creek, at an elevation of 5,000 feet. It contains two parallel veins, 100 feet apart, and each 20 feet wide, vertical and striking S 50° W; and a single vein about 30 feet wide, vertical and striking S 50° E. The veins, occurring in the Creston formation, are composed mainly of quartz with very little, if any, sulphides. The country rock is an argillaceous quartzite, well-bedded and massive.

[1] Summary Report, 1909, Geol. Survey, p. 138.

PLACER DEPOSITS.

Renewed activity in placer mining was seen on Perry creek. In addition to the hydraulicing plant of the Perry Creek Hydraulic Mining Co., Ltd.[1], a steam shovel, situated on Perry creek about 6 miles above Old Town (now called Perry Creek), after some years of idleness was put in operation during the season of 1910.

SHALE.

At Wycliffe, shale of the Creston formation, suitable for the manufacture of fire-bricks, is exposed in a railway cut. It is reported that bricks made from this shale have been successfully used in the burner of the saw-mill at Wycliffe, and in the smelter furnaces at Marysville.

MARBLE.

Situated about 1½ miles north of Wycliffe is a small area of white marble, produced by the contact effects on limestone of a granite porphyry which is here intruded into the Creston sediments. The marble is white to grey in colour, and is practically free from secondary minerals, although garnet and epidote, associated with a little pyrite and chalcopyrite, are developed immediately along the contact.

LIMESTONE.

About 16 miles up Whitefish creek a band of limestone of the Moyie formation outcrops in the creek. It is a white siliceous crystalline limestone weathering a buff colour. The band is about 100 feet wide, and would be of value for a flux, or the manufacture of lime.

CLAY.

Large quantities of clay, occurring in the Pleistocene river deposits on Perry creek and St. Mary river, could be used for the manufacture of bricks and stone-ware.

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[1] Geological Survey Summary Report, 1909, p. 138.

ICE RIVER DISTRICT, BRITISH COLUMBIA.

(John A. Allan.)

According to instructions, a survey was begun on a sheet which will include the Ice River district and the area about Field, B.C. The field season was comparatively short, extending from the middle of June until the middle of September. In order to become familiar with the various sedimentary series across that part of the Rocky Mountain belt, a rapid survey was made during the first two weeks along the Canadian Pacific railway, between Golden and Banff, the section worked up in 1886 by R. G. McConnell. July and August were spent in the Ice River area proper, which is important because it contains one of the very few igneous intrusive masses which are at present known in the whole of the Rocky Mountain belt. The igneous mass is of the alkaline type, and contains sodalite deposits; this mineral has a limited occurrence in Canada. During the remainder of the season a reconnaissance was made up Ottertail river, McArthur creek, over McArthur, Duchesnay and Dennis passes to Mt. Stephen, for the purpose of connecting up the sedimentary series in Ice river with those already determined on Mt. Stephen by C. D. Walcott.

The topographical map used was that issued by the Department of the Interior, in April, 1909, on a natural scale of $\frac{1}{158000}$, or approximately 2 miles to 1 inch, contour interval of 250 feet. This map was enlarged to 1 mile to 1 inch for field use. As the field examination of the area is not yet complete, final conclusions cannot be given on many points.

The writer was efficiently assisted by Mr. Fred. J. Barlow.

LOCATION AND HISTORY.

The area examined in the field season of 1910 is situated on the west slope of the Rocky Mountain belt, and is separated from the Rocky Mountain trench[1] by the Beaverfoot range. It includes about 100 square miles, and lies almost entirely within a 15 foot rectangle between 51° and 51° 15′ north latitude, and between 116° 15′ and 116° 30′ west longitude. It is within the Yoho park, which is reserved by the Dominion Government, and is located within East Kootenay district and Golden mining division. Ice river is readily reached by a good pack trail from Field, or from Leanchoil, which is 17 miles west of Field, on the railway, where the trail leaves the railway and follows up the northeast side of the Beaverfoot valley for a distance of 12 miles, where it crosses Ice river. This trail has been in use for over half a century, and was originally used by the Stoney and Kootenay Indians, and is known as the Kootenay trail. It continues southward down the Kootenay valley to Fort Steele.

The district has never been examined in detail. G. M. Dawson, in 1885, made a hasty visit to the mouth of Ice river, and his observations are included in his preliminary report which appeared in the Annual Report for that year.[2] He notes the intrusive mass, with the occurrence of sodalite, and gives the probable extent of the igneous body. R. G. McConnell worked out the well-known geological structure section across the Rocky Mountain belt in the vicinity of the 51st parallel.[3] During the last three years C. D. Walcott has studied the Cambrian sedimentary series about Field

[1] R. A. Daly. Nomenclature of the North Amer. Cordillera between the 47th and 53rd Parallels of Latitude. Geog. Jour. 1906, p. 576.
[2] Annual Report, Part B; 1885, p. 122.
[3] Annual Report, Part D; 1886.

and east on the Canadian Pacific railway, and his accurately measured sections have since been printed by the Smithsonian Institution.[1] The district has been thoroughly prospected during the last twenty years. Many small pockets of ore have been opened up, some of which will be described under economic geology. Prospecting has, however, been abandoned in the last two years, as the ore was not found in paying quantities. The district is especially known because of the somewhat rare occurrence of sodalite, which is found in the intrusive mass. This beautiful blue mineral has attracted many tourists into the valley, who wished to obtain specimens of this decorative stone. Ice River valley, and its parallel to the south—Moose Creek valley—are known locally as good hunting grounds.

General Character of the District.

The area under consideration lies to the south of the Canadian Pacific railway, to the west of Field, in a range of mountains, a part of which has been called the Ottertail mountains.[2] This range is continued to the northwest in the Van Horne range which is parallel to the Rocky Mountain trench.[3]

The topography of this area is very rugged, and characteristic of the Rocky mountains. Relief is very distinct. The whole district is maturely dissected, and the interstream areas have been worn down to very narrow knife-like ridges, which in many places are not a foot in width.

The intervening ridges rise from 8,000 to 11,500 feet above sea-level. The interstream divides have a fairly uniform elevation of 8,000 feet. The highest peak in the area is Mt. Goodsir—11,676 feet. Other peaks in the area over 10,000 feet high are Chancellor peak, Mt. Vaux, Hansbury peak, Mt. Sharp, and Helmet mountain. The highest average elevation is in the northern portion of the rectangle, in the range which, since it is parallel to the Ottertail valley, has been called the Ottertail mountains. In general, the average elevation decreases towards the south, and that part of the area along the Beaverfoot valley rises about 8,000 feet above sea-level. The drainage system is important, and characteristic of the region. It is largely dependent upon the geological structures.

The principal stream valleys follow the trends of folding. Beaverfoot and Ottertail rivers have a northwest and southeast trend, which corresponds to the major axis of folding in the Rocky Mountain belt. Ice river, Moose, Goodsir, and McArthur creeks, have a north and south trend, which corresponds to the axis of a later period of folding. Other smaller valleys have a northeast-southwest trend.

The valley of the Beaverfoot averages 2 to 3 miles in width; it is faintly terraced on both sides. This valley is continuous with the Kootenay valley to the southeast. The divide between the Kootenay and Beaverfoot rivers can scarcely be located, and the head branches of these streams interlock with each other. The summit has an elevation of 4,000 feet, or 250 feet above the mouth of the Beaverfoot. The Beaverfoot follows a narrow but tortuous channel over the bottom of the valley. It is joined by Ice river 12 miles from its mouth, and by Moose creek 6 miles farther up the valley.

Within 2 miles of their points of junction with the Beaverfoot the courses of these two streams turn sharply to the southwest. These facts seem to strongly suggest that the drainage has formerly been to the southeast, and a slight uplift has caused the Beaverfoot to capture some of the streams at the headwaters of the southeastward drainage system.

Ice river, which has been very appropriately so named on account of the extreme coldness of the water at all times of the year, and Moose creek. head in small hanging

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[1] Cambrian Geol. and Palæontology, Smithsonian Inst., Vol. 53, No. 1812, 1908.
[2] G. M. Dawson, Annual Report, Part B, 1885, p. 122.
[2] R. A. Daly, Geog. Jour., 1906, p. 596.

glaciers, which are the last remnants of the continental ice sheet. The valley of the former is about 8 miles long; both are U shaped and have been carved out by the ice. The former existence of a valley glacier is suggested by the number of hanging valleys on the sides of both valleys. Many of the side tributaries head in glacial cirques or rock basins, some of which are readily recognized on the map; but many of the finest are too small to show on a map of this scale. Small blocks of ice may still be found in some of these cirques. Remnants of the British Columbia ice sheet are seen in the Washmawapta snowfields and the glacier at the head of Ice River valley The former lies on the east side of Moose creek and towards the head of the Ottertail; it covers an area of about 8 square miles, including smaller masses to the northwest. The glacier at the head of Ice river covers about 5 square miles, is deeply crevassed, and has a visible thickness of at least 1,500 feet. The water coming from under the ice is loaded with silt, which it deposits on the floor of the valley below. The glaciers are decreasing in size. Glacial striations and groovings are not found, on account of the rapid rate at which erosion is proceeding in this part of the mountains.

The side tributaries are fast eating back into the intervening ridge, forming in some cases large fan-shaped talus slopes, some of which are 1½ miles long, with slopes from 30° to 50°. The intervening divides are narrow, and in many places less than 2 feet wide.

Timber line is between 6,500 and 7,000 feet. The lower levels are heavily wooded with a second growth of spruce, balsam, fir, and aspen; underbrush of many kinds abounds in the valleys.

The summer season is very short, as snow begins to fall early in August, and the upper parts of the ridges are pretty well covered until the first of July, while many slopes and cañons retain snow in patches throughout the year.

Big game is becoming abundant, as it is protected within the park limits. It consists of goats, deer, grizzly, black and cinnamon bears, moose and caribou. Of these goats are especially abundant, and may be seen in large flocks on rocky slopes above timber level. Small game includes the beaver, lynx, coyote, wolverine, martin, mink, marmot, and porcupine. The last three named are abundant. Beaver are becoming abundant in the Beaverfoot and Kootenay valleys.

General Geology.

TABLE OF FORMATIONS.

As the correlation is not yet complete, only a general classification can be given, which is as follows:—

Pleistocene, and Recent	Stream deposits.	
	Glacial drift.	
Post-Cambrian	Dyke intrusions.	
	Alkaline intrusion.	
Cambrian (Upper?)	(4) Alternating hard and soft bands of argillaceous, calcareous, and siliceous shale, weathering light yellow, grey, and buff	2,975 feet
	(3) Thin-bedded siliceous dolomites and dolomitic limestones dense and hard; especially developed in Mt. Goodsir	6,040 "
	(2) Massive blue limestone with shaly bands	1,550 "
	(1) Thin-bedded grey argillaceous slates weathering yellowish buff, underlain by dark grey argillaceous shales and slates	1,160 "
	Total thickness	11,725 feet

CAMBRIAN (UPPER?)

The oldest rocks in the area are sediments of Cambrian age, with a total thickness throughout the area of about 11,700 feet. They represent a distinctly conformable series, which can be easily subdivided into four separate formations, as shown in the

table. As the examination is not yet completed they have not been given names. The beds are for the most part calcareous or dolomitic, and argillaceous. An almost complete section of the series is exposed on the west slope of Mt. Goodsir, with the exception of the first division, which forms the uppermost beds on the east side of Moose creek.

The lowermost beds consist of dark grey to light grey shales at the base, with a silken lustre. Above these are grey slates, which weather reddish, brownish to yellowish, and buff. Many of these slates contain concretions of pyrite; sometimes the pyrite appears in leaf-like impressions along the bedding, and sometimes the concretions are encased in tremolite. This slate cleaves parallel to the bedding, frequently weathering out into large thin flags. Some of these are 4 feet long, 2 or 3 feet broad, and ⅛ to 1 inch thick. The commercial importance of these slates is doubtful, as they become highly discoloured on exposure to the atmosphere. They are especially well exposed in Zinc valley, and in the east base of Chancellor peak, where they form long, even talus slopes.

These slates are overlain conformably by a band of limestone, composed of thick bedded massive blue limestone and alternating thin-bedded dolomites and limestone, which, on weathering, have a furrowed surface. This limestone band is a good horizon-marker, being traceable about the sides of Ice River and Moose Creek valleys. This band thickens towards the southeast. It has a total thickness of 625 feet at the head of Zinc valley, and increases to a measured thickness of 1,550 feet in the creek to the north of Mt. Mollison.

In Mt. Goodsir, and about Ice River valley, the limestone is overlain by thick and thin-bedded siliceous slates, dolomites, and limestones.

Much of this formation is highly fractured, and, the rock being dense, weathers readily into angular fragments. In Mt. Goodsir there is an estimated thickness of 6,040 feet.

To the south of the area these beds are replaced by soft argillaceous and dolomitic slates, which are especially well developed in the more southerly part of the ridge to the east side of Moose creek. For an elevation of 4,000 feet above the valley on the side of this ridge, there are exposed alternating bands of soft argillacous shale which weather readily into gentle slopes, and more resistant dolomitic argillaceous shales which form steeper slopes. These beds give the face of the mountain a distinctly striped appearance. Thirty-two hard bands, and the same number of soft bands, are exposed. Those accessible were measured. The whole formation has an estimated thickness of 3,000 feet. It lies conformable upon the limestone, and is intensely metamorphosed and cleaved. The cleavage planes dip almost vertically and strike S 50° E, while the beds have a general strike of east and west with a dip of 30° S. These beds were originally fossiliferous, but metamorphism has been so extensive that only small fragments can now be found. Metamorphism throughout the sediments seems to have been regional.

The age of the sedimentary rocks in the area cannot yet be definitely fixed, but from their lithologic appearances they must closely resemble those beds of the upper Cambrian as determined by Walcott in his section in Mt. Bosworth on the Continental Divide.[1] Only one fossil horizon has been found; that is in the uppermost part of the blue limestone band. The specimens found are very poor, and, although they have not yet been specifically determined, they appear to belong to the Cambrian. The fossils include trilobites, and at least one species of a brachiopod and one of a pelecypod. The genus Bathyriscus was determined by Walcott. Furthermore, in a reconnaissance up Ottertail river and over McArthur pass to Mt. Stephen, it was found that the series as exposed in the Ice River area has a higher position than those exposed on Mt. Stephen, which are placed in the middle Cambrian. It seems

[1]C. D. Walcott—Cambrian Geology and Palæontology. Smithsonian Misc. Coll. Pt. III, No. 1812, 1908, p. 204.

probable that the series in question belongs to the upper part of the Cambrian, but, until the correlation is more extensively worked out to the north, they cannot be definitely named. There is no general strike and dip to the sediments in question as the structure is anticlinal. Ore bodies of small size are found in the lower weathering slates, and in the limestone band above these slates.

POST-CAMBRIAN.

Alkaline Intrusive.—As the main object of the survey of this area was to make a study of the intrusive alkaline mass, much of the time was spent on this problem. The igneous mass covers between 12 and 15 square miles; it is very irregular in outline, and is shaped somewhat like a retort. It is an injected body and is laccolithic in character. Its southerly limit is in the north face of Mt. Mollison, where it dips steeply and conformably under the blue limestone band. The contact follows under this horizon-marker of blue limestone to Chancellor peak. Here it pinches out in the form of a sill, in which the lower contact is traceable down to the bottom of the valley of Ice river. This sill projecting from the main mass is 3 miles long, and has a maximum width of 1¼ miles. From the bottom of the valley the contact runs irregularly up the west slope of Zinc mountain, around the head of Zinc valley, and ends abruptly in the side of Mt. Goodsir. The igneous mass covers the whole dividing ridge between the valleys of Ice river and Moose creek, between Mt. Goodsir and Mt. Mollison. The lower contact may be found about 500 feet down the Moose Creek slope, where it conformably overlies the blue limestone, as is the case in Garnet mountain in Ice River valley. There is another small mass of similar syenitic rock exposed at the head of Moose creek between Mt. Sharp and Helmet mountain. This appears to be the lateral extension of the northern end of the main mass.

This alkaline intrusive varies greatly in composition and mineral constituents. The principal type is a normal light grey nephelite syenite; it is especially abundant in Zinc mountain and Sodalite creek. This rock varies through intermediate types into one very basic in appearance, made up almost entirely of basic constituents among which hornblende and pyroxene predominate. This dark type is especially well developed in the sill-like extensions on the west side of Ice river and also along the eastern side of the intrusive. In many places these two extreme types are transitional into one another. The light grey syenite is sometimes found brecciating the darker types, enclosing fragments, and sending dyke-like apophyses into the surrounding rock. These facts suggest that there were disturbing forces at work while the mass was still in a semi-plastic condition. Very few apophyses are found cutting the surrounding sediments. Pegmatitic phases are found in several places throughout the intrusive. Some consist of crystals of nephelite, and a variety of amphibole; others contain very large hornblende crystals. The largest crystals of hornblende observed were 10 to 12 inches long, and biotite 4 inches in diameter. Other minerals noticed in the darker rock types are: sphene, in excellent crystals, magnetite, ilmenite, tremolite, scapolite, zeolites, pectolite, thomsonite, serpentine, schorlomite, and sodalite. A large variety of minerals is expected from a microscopic study of the various types in this alkaline intrusive. Sodalite is an important mineral found in the igneous material; it has a deep blue colour and takes an excellent polish. It is found in places associated with the nephelite syenite, and usually occurs on or near the contact of the normal rock with the sediments. It occurs both as a mineral constituent of the rock and also as veins of almost pure sodalite. Very thin stringers may be found extending several yards from the contact. A few very small veins were found in some of the surrounding sediments. A 6 inch boulder of almost pure nephelite and cancranite was picked up near the head of the valley of the Ice river. Its position suggested that the fragment was derived from a rock-body lying to the north of the mass already mapped.

On the contact between the igneous rock and the limestone there is sometimes a band of dark reddish, dense, hard hornfels, which varies in width from a few feet to a maximum of 300 feet. It has always been found conformable with the limestone above, but the igneous body has both conformable and cross-cutting relations with the hornfels band. Microscopically, the hornfels is seen to contain muscovite, sericite, diopside, calcite, epidote, chlorite, and quartz. This band is provisionally regarded as representing the contact phase in originally calcareous sediments. Fragments of the hornfels were found enclosed in the igneous rock near the contact. Near the upper surface the igneous rock has also enclosed fragments of the limestone, which have become crystallized with a development of calcite, hornblende, and siderite.

The cross-cutting relations can be seen at the head of Zinc valley. A few apophyses also cut the siliceous and dolomitic slates on the side of Mt. Goodsir. It seems evident that the dark type of igneous rock, which represents the femic pole of the magma, was the first to solidify. It appears, however, that all varieties of types belong to one period of intrusion, as suggested by the transitions between types. These transitions may be gradual or sudden; they possibly represent immiscible portions of the magma. There is sometimes fluxional structure in the femic phase.

DYKES.

There are very few dykes in this area. Those noted are generally under 2 feet in width. They all represent very basic types, and seem to be complementary to the intrusive mass. Some have the form of sills, as they are almost conformable with the bedding of the sediments.

PLEISTOCENE AND RECENT.

The large valleys are floored with glacial detritus. This detritus in Ice River valley is known to extend at least 200 feet above the present stream, which has since cut down its broad course. The silt of the main streams coming directly from under the glaciers has formed local broad flood-plains in their valleys. Some of these plains are over a mile wide, and along the surface the stream quietly meanders. The main streams carry a large amount of sediment in suspension.

The glacial detritus has become partially re-cemented; this is seen in the banks of some of the side streams. The boulders are well smoothed, grooved, and faceted by the action of the ice. Most of the material is of local origin, but there are a few quartzitic boulders, which are similar in appearance to rocks exposed within a few miles. Small terminal and lateral moraines occur around some parts of the glaciers. There appears to be little or no plucking or berg-schrund erosion by the existing glaciers. The cirques are numerous, and are as a rule floored with glacial debris and talus.

STRUCTURAL GEOLOGY.

The whole of the area considered during this season lies within one of the Rocky Mountain folds, which has a general trend of northwest and southeast. The large streams, the Beaverfoot and the Ottertail, follow this trend of folding. A later system of minor folds have their major axes striking almost north and south; it is along these folds that the valleys of Ice river and Moose creek have been developed. Ice river flows in an anticlinal valley. The anticline pitches towards the south. In Moose Creek valley the strata are synclinal towards the head, and anticlinal towards the outlet of the valley. The inter-stream ridges, and many of the higher mountains, are synclinal or monoclinal.

The cleavage in the sediments, especially about the intrusive mass, is approximately parallel to the axes of these folds. This period of folding appears to have come

after the igneous intrusion, for a fragment of the syenitic rock was found enclosed along a plane of cleavage in the limestone on the top of the ridge to the south of Chancellor peak.

A shifting in the direction from which the pressure came seems to have formed other folds, and to have cleaved the argillaceous shales and slates in the direction S 50° E. Many of the sediments, especially the thin-bedded limestones, are crumpled and contorted, which on the weathered surface show miniature folds and faults.

From the present observations it appears that the intrusion came after the main period of mountain building, and was followed by a later period of folding, which was probably caused by the intrusion.

Larger faults are few in number and have small displacement. Those observed were either normal or reversed. Small breaks and slips are numerous, especially in the dense slates in Mt. Goodsir.

Economic Geology.

METALLIFEROUS DEPOSITS.

The small prospects which have been opened up in Ice River area show that the mineralization is not extensive. It is confined to the blue limestone and the underlying slates. A note will be sufficient on each of these. The workings on Mts. Stephen, Field, and Dennis were also visited; of these the Monarch mine of Mt. Stephen is alone of importance, and is the only property which has been worked during this season.

PROSPECTS IN THE ICE RIVER AREA.

Waterloo Mining Claim.—This property is located near the head of Moose creek, on the west side of the valley, at an elevation of 7,100 feet. The workings consist of two tunnels 250 feet and 50 feet long respectively. The ore-body, so far as the limited exposures showed, forms a continuous bed, conformable with the bedding of thin bedded hard, dense, quartzitic limestone, with strike of N 15° E and dip 42° N. Where seen, the ore-body was about 6 feet thick. The ore minerals are sphalerite, galena, chalcopyrite, pyrrhotite, arsenopyrite, and pyrite, and are usually found in separate zones of almost pure material. The pyrite is well crystallized. The gangue minerals are calcite, with some quartz sparsely disseminated through the ore. The values which have been obtained are reported to have been in copper and zinc, with low values in gold.

ZINC VALLEY MINING CLAIM.

This is only a small prospect driven 15 feet into the yellowish buff weathering slates on the south side of Zinc valley, but seems worth mentioning on account of the position of the minerals in the ore body. A band of siliceous limestone about 15 feet thick is interbedded in the slates, which strike N 75° W and dip 30° S. This less resistant band has been squeezed into lenticular masses. The mineralizing solutions have replaced the lower portion of one of these lenses. The opened up portion of the ore body is 8 feet in maximum thickness. It appears to pinch out about 15 feet down the dip. The surface outcrop of lenticular form is about 60 feet long. The ore minerals are sphalerite, galena, pyrite, chalcopyrite, arsenopyrite, and native arsenic; the gangue is calcite and quartz in small amounts. The pyrite forms a layer on the foot-wall about 1 foot thick, and a thinner one on the roof. Within the pyrite zone is one of arsenopyrite and native arsenic, which in the upper part is almost free from minerals of the other zones. The central zone contains sphalerite, with some galena and chalcopyrite. It is very irregular, sending short branches into the surrounding zones. Other pockets of ore have been found in this band of siliceous limestone in the slate.

SHINING BEAUTY MINE.

This property has been abandoned for two years. It was owned and worked by the Labourers Co-operative Gold, Silver, Lead, Zinc, and Copper Mining Company of Golden. The mine is located about 3 miles north of the bridge over Ice river, at the head of the first large creek entering from the west. A wagon road was built from Leanchoil to Ice river, with the intention of extending it up to the mine, but it was never completed, and it is now used only as a pack trail. The workings are between elevations 6,500 and 7,500 feet, and consist of three almost parallel tunnels, one above the other and about 200 feet apart. The upper one is 375 feet long, the middle one is 450 feet, and the lower one about the same length. They follow closely along the strike of the limestone, which is N 35° W and dip 72° W. A vertical vein, about 2 feet wide, of calcite, containing zeolitic material, fills a fissure in the limestone almost parallel to the strike. Pyrite and galena were the only minerals visible. Reported values are $20 in silver, zinc, and lead. Pockets of almost pure pyrite, arsenopyrite, and some bornite are found in the limestone.

MONARCH MINE.

The Monarch mine is situated on the precipitous face of Mt. Stephen, about 3 miles east of Field and 1,000 feet almost vertically above the Canadian Pacific railway. It is reached by a trail which leaves the railway about half a mile farther east on the base of Cathedral mountain. The trail passes around the cliff, clinging to the slightly projecting harder bands of blue siliceous and dolomitic limestone, and supported in places by brackets. It finally reaches this apparently inaccessible point at which the ore body outcrops, and from which a tunnel has been driven into the mountain.

The property is owned and operated by the Mt. Stephen Mining Syndicate, with Mr. James Crudders in charge. This mine is one of the earliest opened in British Columbia, and was first worked in 1885. During the past three years development has been carried on part of each year. More extensive developments have been carried on during the past year, and the first shipment of ore was made to the Trail smelter in the spring of 1910.

The ore body occurs in a broad band of bluish limestone which on the weathered surface is slightly pinkish in colour. This band is in the Cathedral formation, which is middle Cambrian.[1] Development consists of about 500 feet of tunnelling. The rock is fissured nearly vertically, and in one of these fissures the ore body occurs. The limestone is brecciated on both sides of this fissure and the fragments are cemented with calcite and ore minerals, which are argentiferous galena, with some sphalerite. The ore body is almost vertical. Its thickness is irregular—in one place as much as 15 feet. Pockets several feet in diameter of almost pure galena have been found.

The following assay from a representative sample was given by the Provincial Mineralogist in his report for 1909.[2] Gold, 0·04 ounce; silver, 6·0 ounces; lead, 50 per cent; zinc, 15-18 per cent; iron, 1-2 per cent; sulphur, 12-14 per cent; silica, 1-2 per cent; lime, 4-6 per cent. The syndicate has an air compressor at the side of the railway, which is operated by two gasoline engines. The ore is taken around the cliff on a narrow tramway and dumped down a chute with a slope between 35° and 40°, which is partly built under the talus and through solid rock to an ore bin at the side of the railway. The syndicate expects to build a concentrator at the base of the mountain in the near future. The zinc blende is intimately associated with the galena.

Other Prospects.—On Mt. Field several prospects have been opened. In the Black Prince claim a short tunnel has been driven along a vein, which cuts almost perpen-

[1] C. D. Walcott—Cambrian Geology and Palæontology. Smithsonian Misc. Coll. Pt. III, No. 1804, p. 4.

[2] Annual Report—B. C. Bureau of Mines, 1909, p. 98.

dicular to thin bedded black limestone, producing conditions somewhat similar to those on Mt. Stephen. The vein, 2 to 3 feet wide, is of almost pure argentiferous galena. Further development of this property is expected in the near future. Other prospects on Mts. Field, Stephen, Dennis, and Ottertail river contain chalcopyrite, bornite, azurite, malachite, pyrite, pyrrhotite, and arsenopyrite, with quartz and calcite gangues.

BUILDING AND ORNAMENTAL STONES.

Slate.—The grey slates in the lower part of the sedimentary series as exposed in Zinc valley and the slopes of Chancellor peak may prove of economic value as roofing material, if experiment proves them to be non-fading.

Syenite.—The normal syenite, which is comparatively free from fractures, would make a good stone, either for building or ornamental work. The amount of this material is unlimited.

Sodalite.—This mineral has a beautiful blue colour, it takes an excellent polish, and the purer material has a handsome appearance in jewelry. This mineral, as has been previously stated, is found in different localities in the border of the syenitic mass. In every case it is apparently associated with the igneous contact. Where it occurs as a mineral constituent of the nephelite syenite, this rock becomes important as a decorative stone. The sodalite also forms veins of pure mineral, varying from a fraction of an inch to an inch and a half in width. In some veins of almost pure material an undetermined brownish mineral may be seen. A small boulder of pure sodalite and cancranite was found near the head of Ice River valley, an occurrence which suggests that the sodalite of some localities is not directly in contact with the igneous rock. Minute veinlets of sodalite are found in some of the sediments a few yards from the contact. It appears that the mineral has been brought in by pneumatolytic action at the close of the intrusion of nephelite syenite. An analysis was made of this mineral from Ice river by Dr. Harrington. It is similar to sodalite found in the nephelite syenite of Mount Royal. The formula of the sodalite as derived from analyses is $3Na_3O, Al_2O_3, 2SiO_2 + NaCl$.

The following analyses of the sodalite from these two localities,[1] and also that from Dungannon, Ontario,[2] have been made by Harrington.

	Ice River.	Montreal.	Dungannon.
SiO_2	37·52	37·50	36·58
Al_2O_3	31·38	31·82	31·05
Fe_2O_3		0·01	
FeO			0·20
CaO	0·35		
MgO			
Na_2O	19·12	19·34	
Na_2O_3			24·81
Na	4·48	4·61	
K_2O	0·78	0·27	0·79
Cl	6·91	7·12	6·88
SO_3			0·12
H_2O			0·27
Insoluble			0·80
	100·54	100·67	101·50
Specific gravity	2·220	2·293	2·295

[1] B. J. Harrington, Trans. Roy. Soc. Can. Vol. 4, Sec. iii, 1886, p. 81.
[2] B. J. Harrington, Am. Jour. Sc. Vol. 48, 1894, p. 17.

Before the material can be considered of economic importance, it will be necessary to find out its extent, which can only be ascertained by development of the property. This occurrence is worthy of consideration, as the material can be inexpensively worked, and the transportation problem is not a difficult one. Part of this sodalite property has been located by Mr. M. Dainard, of Golden.

LAKE MINNEWANKA SECTION.

(Hervey W. Shimer.)

LOCATION OF AREA.

Lake Minnewanka, or Devils lake, is about 9 miles northeast of Banff, in the Rocky mountains, western Alberta. It lies in a long, narrow valley, which in a generally east and west direction forms a pass through the ranges from the foothills westward to the Bow River valley. The lake itself occupies the western half of the valley, with a length of 11 miles, and a nearly uniform width of half a mile. Here the valley of the eastward flowing Bow river is continued in the valley of Lake Minnewanka, and this long southwest-northeast trough is crossed by the northwest-southeast valley of the Cascade river, and the southward bending Bow. Bankhead, with its coal mines, is in the valley, 2 miles west of the western end of the lake. The higher mountain tops of the region vary from 8,000 to 9,000 feet in altitude, with Mt. Aylmer exceeding 10,000.

The section here studied embraced the southern termination of the Palliser range where it rises from the northwestern shore of Lake Minnewanka, and the eastward continued valley of this lake.

PREVIOUS WORK.

In 1886 G. M. Dawson[1] published a 'Preliminary Report on the Physical and Geological Features of that Portion of the Rocky mountains between latitudes 49° and 51° 30′.'

In that report the general physiography of the region here under discussion was outlined in the chapters on the Bow valley, and on Devils lake and vicinity, and the general geology is indicated on the map in two stratigraphic groups: (1) the Kootanie, the Cretaceous coal-bearing rocks, and (2) the Limestone series, Carboniferous, and Devonian.

These larger groups were somewhat subdivided by McConnell[2] in the diagram of a section measured across the mountains eastward from the Columbia valley to the gap of the Devils Lake valley. The formation here given of the section along the valley of Lake Minnewanka are: (1) Cretaceous of the Cascade trough, (2) Banff limestone (Devono-Carboniferous), (3) Intermediate (Devonian), and (4) Castle Mountain group (Cambrian).

In the geologic map of the Cascade coal basin included in his report on this basin, D. B. Dowling[3] gives as the geological section below the Kootanie the following:—

Fernie shale—Jurassic.
Upper Banff shale—Permian?
Rocky Mountain quartzite }
Upper Banff limestone }
Lower Banff shale } Carboniferous.
Lower Banff limestone }
Intermediate limestone—Devonian.
Castle Mountain group—Cambrian.

The work of the summer of 1910 was undertaken for the purpose of determining with greater definiteness and detail the age of the various formations from the Upper

[1] Geol. and Nat. Hist. Surv. of Canada, Ann. Rept. for 1885, part B, 169 pp.
[2] R. G. McConnell, Ibid, Ann. Rept. for 1886, part D, 41 pp.
[3] 1907, Geol. Surv. of Canada, sess. paper 26*b*.

Banff shale to the Intermediate limestone, inclusive, to distinguish the boundaries between them, and to correlate their faunas with those of corresponding formations in other parts of America and elsewhere. To this end the formations were measured and examined in detail, and a representative set of fossils was collected from each bed in which they were found.

Geological History of the Region.

The history of this region, so far as the rocks of the eastern Rockies are concerned, began with the submergence of the entire area beneath the sea, for the Cambrian dolomites of the Castle Mountain group contain marine fossils. If the upper Ordovician and Silurian were periods of deposition for this region, all of these sediments must have been eroded before the area was again covered by the sea during the deposition of the Intermediate and Lower Banff limestones, partly at least of Devonian age. The region remained beneath the sea during the Mississippian, Pennsylvanian, and Permian, that is, during the deposition of the Lower Banff shale to the Upper Banff shale inclusive.

The sea was apparently never very deep, since minor cross-bedding occurs at intervals throughout every formation, mostly in the coarser grained beds, the calcarenites; the presence of coral reefs furnishes a similar argument. During the time of the Lower and Upper Banff shales one or more large rivers entered this sea, carrying quantities of mud. The mixture of this mud and the lime from the organisms then living should give in some of these areas a perfect natural cement. Taken as a whole, this sea became gradually shallower from the time of the deposition of the Lower Banff limestone to that of the Upper Banff shale. The coral reefs are most conspicuous in the upper portion of the Upper Banff limestone, while above this the proximity of the shore is indicated by the appearance of quartzite beds, showing the presence of sandy shores; these quartzite beds become thicker, and with progressively thinner limestone beds separating them the higher the Rocky Mountain quartzite formation is examined. About 50 feet below the top of this formation a few pebbles make their appearance with the sand; these grow into almost conglomerate beds at the top.

The succeeding condition for a part of this area at least was bog-like for a time, as about 5 feet of unevenly bedded quartzites, very full of iron nodules, separate the quartzites from the shales above. During the deposition of the Upper Banff shales the region remained more or less continuously beneath the sea, as marine fossils occur through it. The presence of Lingulæ apparently indicate a near shore deposit; these Lingula beds are likewise usually cross-bedded and ripple marked. Mud cracks are rather abundant, but were never found associated with fossils; these may indicate that this was a land surface for a time.

During probably a part of the Permian, the Triassic, and lower Jurassic, this area was land. In the upper Jurassic sediment was again deposited in the sea, forming the Fernie shale. During the Comanchean period the warping of the land surface caused the deposition of the continental formation, the Kootanie, with its coal measures indicating swamp conditions during a portion of the time, while during the Cretaceous (upper Cretaceous) the sea again invaded the region, leaving remains of the life then inhabiting it in the Upper Ribboned Sandstone deposited at that time. At the close of this period, this region, together with the entire Rockies, was elevated, folded, and faulted. The fault blocks here trend approximately north-northwest to south-southeast, with the strata tilted to the west at an angle of about 45°. Since this time of elevation the weathering agencies have worn away the softer rocks—the Fernie, Kootanie, and Cretaceous—more rapidly than the limestones, so that remnants of the former are now confined largely to the valleys, while the limestones and quartzites occupy the tops of the mountains.

LOCATION OF SECTIONS.

Since all the formations could not be studied in their entirety by making a cross section across any single fault block, sections were made across four blocks, with two minor sections for correlation.

Section I was made along the road and Cascade river from northeast of Bankhead to the junction of the river with Devils creek, the outlet of Lake Minnewanka. This gave an excellent section of the Upper Banff shale and the upper portion of the Rocky Mountain quartzite; the remainder of this latter formation and the upper part of the Upper Banff limestone were studied upon the western side of the river about 1½ miles north of its junction with Devils creek. The two parts of this section were connected by a common datum plane so that the measurements could be made exactly.

Section II began at the Cascade river just south of its junction with Stewart cañon, and was continued east-northeast along the north shore of Lake Minnewanka, that is, along the southwestern edge of the Palliser range, including the southern edges of Mount Astley,[1] the Castle,[2] and Mount Standly.[3] This section gave excellent exposures of the Upper Banff limestone (except the uppermost portion), Lower Banff shale, Lower Banff limestone, and much of the Intermediate limestone.

Section III was made rather hurriedly up the southern slope of Mount Aylmer, at the western edge of the head of Aylmer cañon. Its purpose was to get the contact between the Upper Banff shale and the Rocky Mountain quartzite, and to note if any variation had occurred in this distance in the thickness of the beds and in the detailed succession of the fauna in the Rocky Mountain quartzite and the Upper Banff limestone.

Section IV was made along the northern edge of the valley forming the eastward continuation of the Lake Minnewanka valley. The section extended from the gully at the western end of Middle lake,[4] westward along the foot of the mountains. The purpose of this section was mainly to get the lower part of the Intermediate limestone and its relation to the Castle Mountain group below.

TABLE OF FORMATIONS.

The rocks of this region are entirely of sedimentary origin; the seven formations studied consist almost entirely of limestones and calcareous shales. The following correlation of the formations is provisional; a thorough study of the fossils collected will be necessary before the correlation can be made accurate.

Permian		Upper Banff shale.
Pennsylvanian	Carboniferous	Rocky Mountain quartzite.
		Upper Banff limestone.
Mississippian		Lower Banff shale.
		Lower Banff limestone.
Devonian		Intermediate limestone.
Cambrian		Castle Mountain group.

[1] The name applied locally to the peak between Stewart cañon and the western end of Lake Minnewanka. It was given in honour of Mr. C. D. Astley, who lived at its southern foot for twenty years.

[2] Locally applied to a castle-like cliff, as seen from the lake, east of Mount Astley, formed of almost horizontal strata and separated from the rocks east and west by ravines.

[3] A name applied to the prominent projection just west of Aylmer pass, between the pass and the lake. The name is given in honour of Mr. John Standly, who was the first to operate profitably on this lake a boat for the accommodation of tourists, and thus assured the continuation of this accommodation.

[4] There are three lakes in this valley between Lake Minnewanka and the Devil's Gap, which are named West, Middle, and East lakes respectively.

DISCUSSIONS OF FORMATIONS.

Upper Banff Shale.

An alternation of heavy bedded, light grey, calcareous sandstones and thin bedded, dark grey, calcareous-arenaceous shales. The latter are especially conspicuous for their numerous black laminae. The shales often weather reddish. At frequent intervals throughout the entire thickness occur many ripple marks, mud flows, minor cross bedding, and mud cracks.

The contact with the Fernie shale above is apparently very abrupt, though the exact contact was not seen. The topmost hundred feet of the Upper Banff shale is a light grey, heavy bedded, calcareous sandstone, while the lower Fernie is an alternation of black, very fissile shale, and almost black limestone.

The contact with the Rocky Mountain quartzite below is plainly seen in the Mount Aylmer region; here the two formations are apparently conformable, but the change from quartzite to arenaceous shale is rather abrupt, with a very conspicuous development of iron concretions for 5 or 6 feet at the contact.

Marine fossils occur throughout most of the formation, though locally restricted; they are often found in beds varying from 2 to 6 inches in thickness, while above and below they are apparently entirely absent. They are very poorly preserved, and the species are confined to lingulae and pelecypods. The age, as indicated by a brief laboratory examination of the fossils, is Permian, with an apparently Pennsylvanian affinity. Thickness about 1,200 feet.

Rocky Mountain Quartzite.

An alternation of light grey quartzite and light grey limestone, the former predominating in the upper portion, the latter in the lower, where it merges imperceptibly with the Upper Banff limestone. The uppermost 50 feet contain considerable conglomerate, with rounded quartzite and calcareous pebbles up to 2 inches in diameter.

The formation is fossiliferous at intervals throughout its entire thickness, but mostly in its upper and lower portions. All the fossils indicate marine origin. About 10 feet below the top is a very light grey chert bed 2 feet thick, which is one mass of silicified fossils; about half of these are specimens of *Euphemus carbonarius* and would thus strongly argue a Pennsylvanian age, but a further study of the specimens is necessary since some apparently Permian elements are present. Exactly the same association of species here noted in this chert bed is seen in the Pennsylvanian ? of the Toroweap valley in northwestern Arizona. Thickness about 600 feet.

Upper Banff Limestone.

Thin bedded, light to dark grey limestones, fine-grained beds alternating with coarse-grained, and frequently respectively chert-bearing and chert-free. The formation below this becomes more and more shaly until it merges with the Lower Banff shale.

The fine to medium grained limestones are usually fossiliferous, often strongly so. The coarse-grained beds are as a rule free from any indetifiable fossils except crinoid joints. Thickness about 2,200 feet.

Lower Banff Shale.

Predominantly a dark grey to black calcareous shale, weathering brownish. It is typically shale below, while above it becomes more and more calcareous, until with many repetitions of shale and limestone it merges with the Upper Banff limestone.

Fossils are abundant throughout the formation, except the lower 500 feet, where none were noted. Thickness about 1,300 feet.

Lower Banff Limestone.

Heavy bedded, light grey limestone. The upper 150 feet are alternately more thinly bedded and of a darker colour, being thus transitional to the Lower Banff shale.

The formation is fossiliferous, though not conspicuously so, except in the upper portion. Fossils were found at intervals throughout the entire thickness. At about the middle of the formation the rock is very conspicuous for its dolomitic segregations: these look much like poorly preserved forms of pencil-like, branching bryozoans, or corals. Some such segregations occur in most of the beds, as likewise in those of the Intermediate limestone and the Castle Mountain group beneath. Thickness about 1,000 feet.

Intermediate Limestone.

Alternating fine to coarse-grained limestone. The rocks when struck emit a strong odour of hydrogen sulphide.

Comparatively few fossils were noted; about 600 feet below the top they were rather abundant though poorly preserved. These indicate a Devonian age. Thickness about 1,600 feet.

COAL FIELDS OF JASPER PARK, ALBERTA.

(D. B. Dowling.)

Introduction.

Great activity in exploration and prospecting work on the coal areas of western Alberta, in the vicinity of the Grand Trunk Pacific railway, was noticeable during 1910. Although the end of the completed portion of the railway was distant from the mountains about 80 miles, a force of about 20 men was employed on the construction of temporary mining works near Roche Miette, and a force of perhaps 30 men on properties between that point and the Brazeau. In the coal area on the Embarras river little was attempted, on account of litigation between rival companies; but a branch line from the Grand Trunk Pacific railway has been located, and is now being built towards it; so that shortly, it may be expected, prospecting will be resumed.

A great part of the time spent by the Survey party in the field was devoted to inaugurating a triangulation and photographic survey of the outer ranges south of the railway line, hence geological details will be confined mainly to the field thus partially mapped.

This portion, important from an economic standpoint on account of its coal areas, is also of interest to the travelling public as one of the future pleasure and health resorts in Jasper park. Hot sulphur springs, situated within 10 miles of the railway, will probably be utilized for medicinal baths. A suitable location for a town is at the mouth of Fiddle creek; and it is probable that within a few years a resort similar to Banff will be established there.

The data for the topographic mapping was obtained mostly by my assistants, Messrs. W. S. Barrows and L. H. Gass, who proved very energetic in the performance of their duties.

SUMMARY AND CONCLUSIONS.

The Nikanassin basin to the southeast, described in last year's summary, does not continue as a coal field northward past the watershed of the branches of the McLeod river, though the lower beds of the Kootanie formation. occasionally having very thin coal seams, apparently continue through to the next coal basin northward, which crosses the Athabaska river west of Fiddle and Moose creeks.

In the foothills, the upper part of the Kootanie formation which there forms the productive coal measures is brought to the surface in several places, the first of note reported being on the west branch of McLeod river, where seams have been prospected on several small branches. This productive area is interrupted by the anticlinal ridge known as Folding mountain. North of this, in the vicinity of Brulé lake, the rocks in contact with the upthrusted limestones of the first range are found to be lower Cretaceous, and contain the coal measures which are exposed south of Folding mountain. This indicates either a rapid dip northward of the axis of the anticlinal fold, or a transverse break across the direction of the outer ranges. The latter supposition is the more probable, since the formation of the Athabaska valley indicates a line of weakness, and the ledges exposed on opposite sides of the valley do not seem to be exactly in line.

The coal fields in the immediate vicinity of the railway consist, therefore, of two areas, the first, an eastward dipping series of rocks that are the eastern limb of an anticline, the crest of which is almost on the line of the fault in front of the first range.

(The western limb is probably short, and overridden by the Devono-Carboniferous beds.) These rocks slope towards the northeast, and coal exposures have been found north of Brulé lake. Should the seams be found to the south of the lake, their proximity to the railway would be of great advantage in mining.

The second coal field is inside the first range, and, as will be seen from the series of sections in the stereogram (Fig. 5), is divided along its length by a broken anticline.

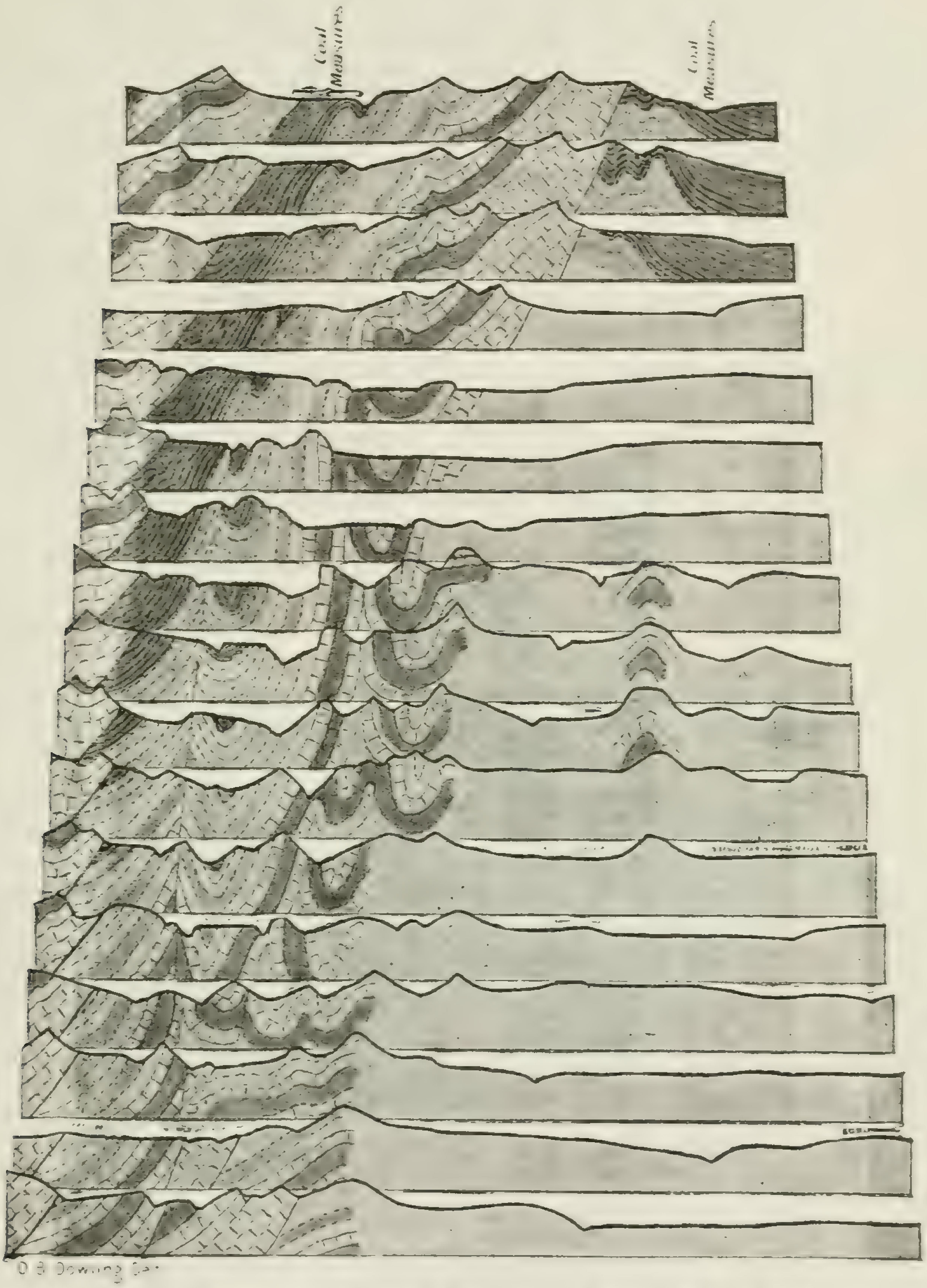

Fig. 5.—Stereogram of Sketch Sections in Jasper Park, Alberta.

This leaves the eastern portion in the form of a narrow basin, in which only the lowest seams may be found. The western part, which is a monoclinal block, presents more favourable conditions for mining by tunnels along the seams from the edge of the valley. Three workable seams of steam coal, in beds of 5, 10, and 13 feet, respectively, have been prospected on the south side, at the Jasper Park collieries.

TOPOGRAPHY.

The area visited this summer forms part of the outer ranges of the Rocky mountains. The deeply eroded valley of the Athabaska river crosses the northern part, and into it drain several streams flowing between the tilted and folded blocks of strata that form the ranges. The tributary from the south—Fiddle creek, which occupies the principal place in the small accompanying map—flows in a very crooked channel, which crosses a pronounced ridge of limestone three times, through narrow cañons. One mountain range lying along the southwestern margin of the district seems to be quite persistent, although its direction changes somewhat at the Athabaska. A flat-topped, cliff-sided point on this ridge, south of the Athabaska, has long borne the name Roche Miette, and forms one of the most striking features in the landscape. Between this range and the foothills the mountains are more irregular, due largely to the geological structure. At the north end of the portion mapped, the outer ridges are the upturned edges of the harder beds of a wide fault block. At the Athabaska river this block shows signs of deformation by longitudinal folds and breaks, which farther south have disturbed the continuity of the ranges. One short ridge, occupying a position in advance of the mountains, is plainly caused by a simple fold of the outer crust, and the arch so formed—a short ridge of limestone exposed by the erosion of the softer rocks of the original surface—bears the descriptive name, Folding mountain.

The general structure of the Rocky mountains from the International Boundary north to about the Saskatchewan river is that of a series of fault blocks, consisting of the same series of rocks, resting against each other. A repetition of form and colour, and a continuity in the ranges therefore obtains; but in going northward, more diversity in the form of the blocks is noticeable. The regularity of dip and repetition of beds, to a great extent, is replaced by folded strata and a greater variety in the outline of ridges.

The foothills near the Athabaska valley are not prominent, and to the south are somewhat irregular, especially near the mountains; to the north the ridges have steep faces towards the ranges and long easy slopes northeastward.

The drainage channels through both mountains and foothills, in many instances suggest breaks in the upthrusted blocks. Thus in the Athabaska valley there is evidence that, through the outer ranges at least, and for some distance through the foothills, there were cross fractures in the fault blocks, now shown principally in an unexact alignment of beds on opposite sides of the valley. The devious course followed by Fiddle creek, crossing, as it does, three times through a ridge of vertical limestone, the first occurring at a distance of less than 3 miles from its mouth, also suggests cross fractures.

The present stream, occupying the Athabaska valley for some distance above Brulé lake, is depositing material along its course, and seems to have partially filled a former lake. Its meandering course through a swampy flat by many channels, with evidences also of discarded ones, suggests that Jasper and Brulé lakes will also at no very distant date become silted up.

Gravel terraces similar to those on the Bow river are found at elevations up to 300 feet above the present river. These, no doubt, belong to the same period as the transported deposits known as the Saskatchewan gravels. The tributary streams entering on each side are moving a large amount of gravel into the Athabaska valley, and in almost every case show a steady growth of the fan deposit near the mouth. Thus, at the mouth of Fiddle creek, the steeper grade of the tributary stream has enabled it to move material towards the Athabaska river that could not be removed by the current of that stream. Consequently the river has been forced over against the rocky walls of the ridges on the north side. At the mouth of Moose creek, a smaller collection of river-borne material forms a flat fan, which occupies a part of

the river flat. This appears to be due to the activity of the current of Moose creek. The large tributaries from both north and south, which enter the Athabaska near Roche Miette, may have been the agents causing the formation of Jasper lake, by moving material into the valley and thus forming an obstruction partially damming back the water. Brulé lake, although it seems to be silting up, has no doubt also been lowered, by the erosion of the barrier at the outlet. This barrier consists of the tilted beds of Cretaceous sandstone, separated by shale, so that it forms a succession of hard ribs. The channel being cut through them from Brulé lake to the mouth of Prairie creek, although having a fairly uniform, heavy gradient, is still in process of erosion where each of the ribs crosses it. The gradient in the channel which has been cut through this barrier steepens perceptibly after leaving the lake, and there are several rapids, but none at the outlet, so that the erosion which is still going on does not immediately threaten the existence of the lake.

NATURAL ADVANTAGES FOR A PARK.

The great importance of the reservation of the timber and game of the country on the eastern slope of the Rocky mountains is generally recognized and need not be enlarged upon here. The ease with which the mountains can be reached by railway offers great inducement to those seeking change for health or recreation, and the adaptability of this area for health and pleasure resorts may be noticed. The scenery of Jasper park, although not of the bold and rugged type of the higher altitudes, is nevertheless pleasing; since the valley of the Athabaska, which is wide and well furnished with lake-like stretches of water, forms a pleasing foreground to a background of mountain peaks with ranges on either side. The approach by railway along the Athabaska river offers ever changing scenic views of river stretches, and wooded hills, above which can be seen the rugged ridges of the outer range.

Along the line of railway townsites will doubtless be selected. The gravel built sloping plane near the mouth of Fiddle creek seems to afford a suitable location for such a town, being not only well adapted for a town site, but also the nearest point to a series of hot sulphur springs on one of the western branches of Fiddle creek. When proper roads have been constructed, these springs may be reached by a drive of about 8 miles, over a picturesque route, affording probably glimpses of the cañon of Fiddle creek and of the wall-sided ridge through which it has been cut. Mountain climbers will find no great elevations to attract them in this part of the park, though a peak just south of the springs has an elevation of nearly 9,000 feet, and affords from its summit an extensive view of the surrounding hills and valleys. Among other attractions for the general tourist there is boating on the lake and river, at present somewhat impaired, however, by the shallowness of the lake, and the strength of the current in the river.

FOREST.

The largest area of green forest, containing timber of marketable size, occupies a triangular stretch of country lying to the east of Brulé lake. The wagon road to Prairie creek runs along its southeastern margin. Along the Athabaska, burnt country extends from the east to a point nearly half way between the lake and Prairie creek. Other fairly large areas of unburnt timber are found within the mountains, on the flat lands through which wind the many channels of the Athabaska river. Another area of green forest, but consisting of patches only, extends from the head of Drystone and Prairie creeks to the western sources of McLeod river. Although throughout the district there are, here and there, small patches of living trees, the greater part of the original forest has been burnt.

TRANSPORTATION.

By the date of the issue of this report, the rails will probably be laid for the Grand Trunk Pacific railway from the east to the crossing of the Athabaska, which point lies west of the limits of the accompanying map. The low water during the winter will be taken advantage of to place the caissons for the pier excavations. During the construction of the piers and superstructure a temporary terminal will be made in the vicinity of, or near the west end of Jasper lake. The necessary construction roads along the line of railway are being made of a more permanent nature in the park, than through the foothills, and, later, they will be maintained by the park administration as wagon roads. The original trails through this district were merely pack trails or paths, along the banks of the river, crossing the streams by fords, which are passable only at low water. The fords were situated, one at Swifts, above the railway crossing, another below Jasper lake, a third at the outlet of Brulé lake, and a fourth at Cache Pecotte, east of the mouth of Prairie creek. Crossings were made, towards the close of the past season, by cable ferry at Jasper House, and by gasoline launch on Brulé lake. Trails follow the valleys of Snaring and Stony rivers on the north, and the Athabaska, Jack creek, and Rocky river on the south, and there are a few in the foothills, including one from Prairie creek to and up McLeod river. An old Indian trail, practically blocked by fallen timber, leads over the hills to Fiddle creek above the cañon, and another follows the east side of the steep, straight ridge through which Fiddle Creek cañon is cut. New trails have been made from the end of the wagon road constructed by the Jasper Park Collieries, to Sulphur creek. These trails were intended to replace the trail up the bed of Fiddle creek, which was very rough for horses, but though they avoid the rough creek bed they cross some very steep hills. A route with easier grades might be found along or near the bank of Fiddle creek, though some rock blasting would be necessary at the cañon. When this road is completed as far as the Hot Springs, and repairs are made to the road from Prairie creek, tourists will be able to reach many of the points of interest.

COMMERCIAL POSSIBILITIES.

Since the area under discussion has been reserved as part of a national park, its commercial development will be effected more directly under Government supervision than other areas; and the coal deposits, which are of importance, will be mined under lease.

The localities of the coal outcrops are very advantageously situated both for mining and shipment, and the demand for coal, after the completion of the railway, will be sufficient to ensure the opening of collieries, so that small mining towns are sure to grow up within the park.

General Geology.

The rocks exposed in the eastern ranges of the Rocky mountains are very similar, over long distances, in general character and age, and it may be remarked that the formations there exposed have been traced almost continuously from the Bow River valley to the Athabaska. Slight changes in the character of the deposits are noticed, but the section, as a whole, is practically uniform. Of the consolidated rocks, all of which were deposited previous to the mountain uplift, the section here includes a sequence of beds from middle Cretaceous measures to and including Devonian limestones. The upper part—that including Cretaceous and Triassic rocks, being of easily eroded strata, does not form any material part of the ridges known as the Rocky mountains. The crests of the ridges are generally of limestone, in thick beds,

belonging to deposits probably of Carboniferous age. The lower limestones in the area shown on the sketch map are probably of Devonian age, and are exposed along the lower scarped eastern faces of the ranges next to the fault by which they are brought up into contact with higher beds, the maximum displacement being where the Devonian is in contact with the upper part of the lower Cretaceous. The complete list of formations which, judging by analogy, will be found to occur in the district, but of which fossil evidence, establishing their age, has not yet been obtained, includes the following:—

Recent	River deposits. Sands and silts, lake deposit
Pleistocene	Boulder clays Cemented gravel (similar to Saskatchewan gravels).
Cretaceous	In the foothills, probably the whole section of the Cretaceous will be found. In the mountains, beds of Kootanie or lower Cretaceous age are exposed.
Jurassic	Shales and sandstones.
Triassic and Permian	Siliceous shales and dolomites.
Carboniferous	Limestones.
Devonian	Dolomitic limestones.

CRETACEOUS.

Kootanie Formation.—The beds of this formation contain the coal seams that are found in the Rocky Mountain areas. The formation as a whole is of fresh water origin, although salt water deposits are not entirely absent. Plant remains are to be found throughout nearly the whole thickness of the measures.

A measured section of the lower part of the formation was made on Villeneuve creek.

The nearest section for comparison is one measured by Mr. Malloch on Chungo (Trail) creek, which occupies a gap near the north end of Bighorn range. The sections in the northern field differ from those in the Cascade coal field to the south, mainly in the presence of a heavy conglomerate band in the central part of the measures, and an increased thickness of sandstone beds in the lower part. Although small seams of coal are found below the conglomerate, none appear to be workable deposits, but above it there are at least three seams that are thick enough to mine.

Comparing the section on Chungo creek with that in Jasper park, there is a similarity in the general nature of the deposits in those portions below the conglomerate band, but there is an increase in thickness in the northern section, assuming that the conglomerate band occupies the same horizon in each. The conglomerate band in the northern field is very persistent, and forms a strong rib, which is often detected in the topographical forms, and is useful in tracing the probable position of coal seams.

The upper portion on Chungo creek is complete to the overlying beds of later Cretaceous deposits, but in the section under examination this season, the thrusting and faulting of mountain building has cut away the upper portion. A complete section may yet be found in the foothills, but the surface covering there is generally thick, and rock exposures are confined to the river valleys.

Section on Villeneuve creek.	—	Bighorn Coal Basin. — Malloch's Section on Chungo creek.[1]	—
Coal seam	10 feet (not dug out.	Shales and sandstones, containing seven seams of coal	2,072 feet.
Sandstone	300 feet.		
Coal	12 "	Conglomerate	12 "
Sandstone	350 "		
Coal	(?) not dug out.	Sandstones, etc	367 "
Sandstone	120 feet.		
Coal	5 "		
Sandstone	350 "	Shales, sandstones, and streaks of coal.	328 "
Conglomerate ridge	50 " about.	Sandstones	672 "
Sandstone and shale	500 feet.		
Streaks of coal—	(?)		
Sandstones and shales	300 "		
Streaks of coal	(?)		
Sandstones and shales	900 "		
Streaks of coal	(?)		
Sandstones	600 "		
	3,497 feet.		3,451 feet.

Jurassic.—Below the lowest, heavy sandstone bed of the section given above, black shales, in which sandstone beds are distributed, are found to hold marine shells—a passage downward from land conditions to salt and brackish water deposits. A sandstone rib, probably 100 feet below the sandstone of the above section, is found to contain marine shells, recognized by Mr. Raymond as being probably *Arctica* (Cyprina) *occidentalis, and Nemodon* cf. *Sulcatinus.*

The first of these is recorded by Mr. Whiteaves from the lower shales of Queen Charlotte islands, regarded now as Jurassic, and the second is probably one of the varieties determined by Mr. Whiteaves under the name *Arca (Nemodon)* from the same beds.

Separated from these sandstones by 100 feet, approximately, of dark shales, lies a second sandstone and shale rib. In this, specimens of *Gryphæa planoconvexa, Ostrea strigicula,* and a species of Terebratulina were found. Of these Mr. Raymond says: 'The fossils and their mode of occurrence strongly suggest the Ellis formation of Montana and the Yellowstone National Park.' The Ellis formation has been considered Jurassic, and this, therefore, furnishes the first correlation between the Fernie shale horizon and the Jurassic of Montana, although previous to this the Jurassic age of the Fernie shale, and of the lower shales of Queen Charlotte islands, has been admitted.

Triassic and Permian.—The sandstones and shales comprising the beds of Jurassic age rest on a series of dolomitic and siliceous shales. Generally reddish in colour, these shales are in this district often bright yellow, shading to brown in the lower beds, the upper light coloured part having occasional thin, bright red streaks or beds. This colouring is probably due to iron oxide, and the variations from red to yellow are merely local expressions of chemical changes, due to differing conditions in the beds during the mountain building. No fossils were detected, and the formation seems almost barren of animal remains.

Carboniferous.—Limestones in two heavy beds, separated by thinner bedded limestones and shales, occupy positions in the section similar to the Upper and Lower Banff limestones. The Lower Banff shale, which in the south separates the limestones, is here of a somewhat less definite character, and it is a question whether it might not

[1] Summary Report, Geol. Surv., 1908, p. 75.

be better, in the northern area, to recast these divisions. The general character of the limestones, in appearance at least, all through these ranges from the Banff locality, is very persistent, so that there is very little doubt about the correlation of the group as a whole.

Devonian.—The beds exposed just below the grey limestone are somewhat similar, particularly in the occurrence of yellow streaks and thick bedding, to the Intermediate beds at Banff, which are of Devonian age; but as no fossils have been found in them the limits of the formation are not yet defined.

Historical and Structural Geology.

The character of the deposits found in the district suggests that in later Devonian and Carboniferous times there was a period of continued submergence by the sea, during which very little detrital matter was distributed. The bands of shale in the limestone formations seem to indicate that during this period there were slight disturbances in the crust, causing the emergence of areas of land elsewhere, from which the waters of the sea received a burden of silt. In the upper part of the Carboniferous formation shallow water deposits are found, indicating a slight rise at that period, concurrent with, probably, a greater elevation of parts of the continent both east and west. The narrowing of this sea, or a near approach to a shore line, is shown by the occurrence of more siliceous material in the beds immediately above the Carboniferous limestone. During the Jurassic period, which elsewhere was a time of great disturbance, no considerable amount of earth movement appears to have taken place in this area, except that the sea was probably still further narrowed, and the water of this narrow sea, or inlet from the northwest, was very much burdened by fine silt, indicating active erosion in some other, possibly the western portion of the continent. The deposits of the early Cretaceous, generally coarse sand and silt, filled this arm of the sea, and the continued continental elevation assisted the rapid shifting of surface material to this broad trough, which, to the south, appears to have been mostly above sea-level, though during early Cretaceous times the flat country near sea-level may, by slight oscillations, have been inundated by the sea; but generally the deposits appear to have been brought to it by fresh water, while its general elevation was near sea-level. A temperate climate is indicated by the abundant plant remains which are preserved in the coal seams.

Elsewhere, the rocks of the Cretaceous indicate that after the period marked by these coal seams there was a widespread subsidence, and, in the central part of the continent, marine beds form a considerable portion of the Cretaceous deposits. A final recovery of elevation marks the close of Cretaceous times, and land conditions then prevailed, and coal deposits were formed, while the surface was at a low elevation. Greater elevation during Tertiary times is suggested by the remains of plants of types resembling the present flora. The deposits in which they are buried are of fresh water deposition, in lake basins and from river flooding.

The Laramide revolution, or the disturbance of the crust during which the Rocky mountains were forced up, succeeds the time of the deposition of the Tertiary rocks of Alberta. A compression of the crust, increasing in intensity, was relieved by folds and breaks that run northwest and southeast, with a general upthrust of the western side. A period of general erosion of the surface, which is still going on, forms the concluding chapter in the geological history of the region.

The outer or eastern edge of the disturbed belt in front of the mountains is nearer the ranges at the Athabaska than it is farther south, on the Brazeau. The faults between this line and the outer range of the mountains form, roughly, a radiating series narrowing to the north. This narrowing may have resulted from changes in the direction of the pressure, or from a greater lateral movement in the southern part. In the outer ranges many of the fault lines, which are the lateral

boundaries of fault blocks, show a diminishing throw northward, until they become folds instead of faults, and merely deform succeeding fault blocks. Thus, at the Athabaska, the fault blocks show on their lateral section several minor folds, the axes of which run parallel to the fault lines. These facts seem to indicate a diminution in the lateral movement of the crust. The appearance of the mountains, too, seems to point to the same conclusion, since their greater folding can thus be interpreted as resulting, not from greater pressure, but from less lateral movement, and, possibly, less pressure.

Economic Geology.

Cement and Lime.—The wide use of cement in the building industry in Alberta has led to the construction of cement works on both branches of the Canadian Pacific railway near the mountains, since the necessary calcareous material is found in very small amounts in the rocks of the plains. The market may at some future time warrant the construction of a similar plant near the line of the Grand Trunk Pacific, since both limestones and shales suitable for cement making are here found, and coal is to be had in the immediate vicinity.

Iron Ore.—Some of the shale bands which separate the heavy bedded limestone formation contain a certain amount of iron oxide. In some cases these beds have a distinctly brownish colour, and samples, showing enrichment of the lower beds by infiltration from higher levels, are found, which could be called ores. These, if found in sufficiently large bodies, may be mined, but exploration sufficient to establish their presence in such quantity has not been undertaken. Claims for iron have been staked on the face of Fiddle mountain, (between Fiddle and Drystone creeks) on a band of iron-bearing black shale which lies between the heavy limestone formations. The greatest impregnation of iron oxide is to be found in a series of siliceous shales between the limestone and the coal-bearing rocks above. As red bands, these rocks have been traced northward from the Kananaskis river, and their greater thickness, compared with the lower shales, should increase the possibility of finding in them mineable portions, though, as a rule, they would be of low grade. The smelting of these ores might be made possible by the reduction of the siliceous material by concentration.

COAL.

Foothills.—The rocks of the Kootanie, which is in general a sandstone and shale formation containing coal seams, are exposed in the foothills near the mountains. The uplift necessary to bring these beds to the present surface was accompanied by the formation, to the east, of a wide syncline in the rocks of the plains. This basin, at the latitude of Edmonton, is wide, but farther south narrows down, and the dip of the beds on either limb of the syncline steepens perceptibly. North of Brulé lake the limestone formation has been pushed up on an anticline of the coal-bearing beds, crumpling and folding the western limb. The eastern limb dips, with lessening slope, beneath higher beds of the Cretaceous. Several coal seams in the upturned edges of the measures in the hill west of Brulé lake have been prospected near and in the valley of Scovil creek. The seams there found have been opened since our visit, with the result that, it is reported, seams having a thickness of 10, 12, and 5 feet respectively, have been discovered. The exposure on Scovil creek was visited, and the seam measured and sampled; the thickness is 9 feet 6 inches and the dip northeast 25°.

The sample was taken by channelling across the whole seam. Some of the dirty layers could be mined out and the ash reduced in the commercial output. Analysis by F. G. Wait, Mines Branch:—,

Moisture	1·09
Volatile hydrocarbons	17·88
Fixed carbon	56·95
Ash	24·08
	100·00
Coke, firm coherent	81·03

It is reported that, in other exposures south of Folding mountain, on one of the west branches of McLeod river, these beds dip towards the mountains and contain beds of coal, including one very thick seam with about 30 feet of coal. The tracing of the measures between these two exposures has occupied the energy of prospectors, and Mr. McEvoy reports the discovery of coal on the south side of Brulé lake, near the railway. No details of any of these seams are yet to hand, except the one seen on Scovil creek.

The Mountain Coal Basins.—Within the first series of mountain ridges a depression or valley, drained by Moose creek, on the north side of the Athabaska, and by branches of Fiddle creek, on the south, is found to be due to the erosion of the softer beds that form the upper members of a wide fault block. In the area illustrated by the accompanying topographic sketch (Fig. 6), the coal-bearing beds of the Kootanie form an upper member of this partly eroded series, and portions are found to remain both in the centre of the valley and in contact with the next succeeding fault block to the west. The fault line, which is the western boundary of the coal area, is generally concealed by detritus from the higher slopes, but its approximate position is indicated by changes in the dip of the beds, and by local folding.

Owing to a differential uplift of the western edge of the fault block containing the coal measures, and to a deformation of the block by an anticlinal fold, the southern end of the block is raised, and the beds containing the workable seams have been eroded. This elevation results also in the cutting away almost entirely of the rocks of the lower part or non-productive portion of the Kootanie formation, so that only a very narrow band, if any, remains to form a connexion with the Nikanassin basin to the south. The measures containing mineable coal seams can be followed near the fault line to a point a short distance south of the crossing of Sulphur creek.

As will be seen in the sketch section, the coal basin is divided by an anticlinal fold along its length. Faulting, with an overthrust of the western part on the eastern, has complicated the form in which the two parts, so divided, are now found. The eastern part is mainly in trough form, but the break along its western edge has probably occurred in the upturned beds of the western limb of the anticline.

The western portion of the field remains generally in the form of a monocline, although remnants of the anticline along its eastern border still remain. It is a wedge-shaped block, narrow to the south but broadening northward, the rocks dipping towards the southwest at fairly constant angles varying from 50° to 70° in different parts of the field. This part occupies the western edge of the fault block, and is overridden by rocks of the next range.

The measures near the western fault are sometimes upturned, and probably folded back, especially in beds exposed on the higher spurs. Those near the fault at lower elevation are probably overridden by the limestone, and show less disturbance. The strong ribs of sandstone, and the rib of conglomerate near the base of the productive coal measures, form prominent ridges and show a continuity that argues well for the condition of the coal in their proximity; the lower seams, therefore, at least for this block, should be mineable south from the Athabaska to Villeneuve creek. Northward the block appears to widen, and should be, from that fact, of greater value as a coal field, since higher beds may be exposed and a greater number of seams found. Up to the present, the greatest amount of prospecting has been done south of the Athabaska river.

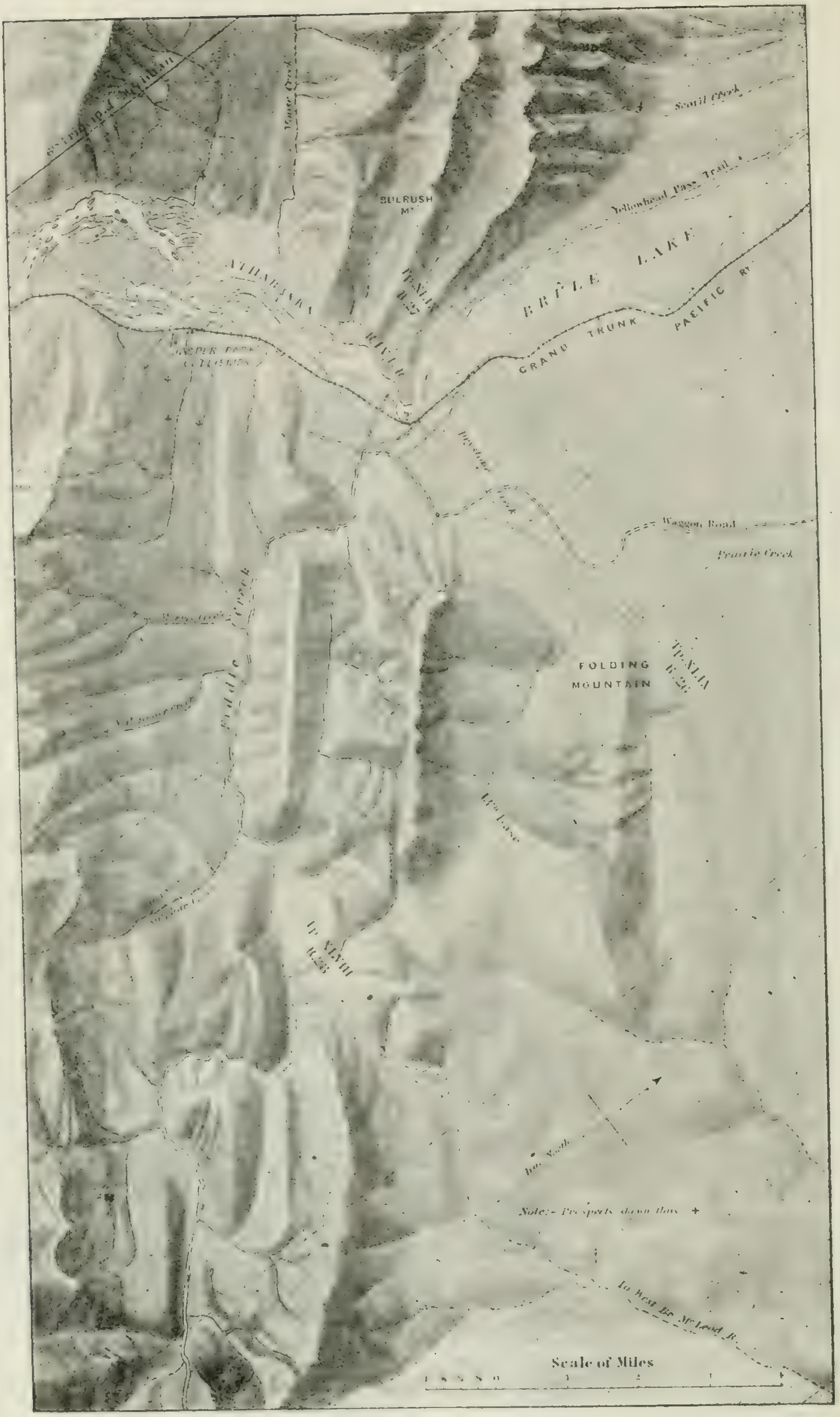

Fig. 6—Topographical Sketch of a Portion of Jasper Park, Alberta.

The eastern part of the coal field is in the form of a trough, the southern end of which is elevated, and, south of Villeneuve creek, eroded away. On that creek the trough is too shallow to warrant the expectation of finding in it mineable coal seams, but on Morris creek it is much wider, and the beds of the eastern limb of the syncline are not so much disturbed as those of the western limb. The inference, from the exposed part of the section, is that the upturn on the west was accompanied by faulting, and that this fault line, which separated the two coal areas, reached nearly to the Athabaska valley, and probably terminated there. The section on Villeneuve creek shows an upturn of the beds on the western limb of the syncline, but after a short interval of concealed beds, lower sandstones are found dipping to the west in conformity with those of the block next the mountains. This indicates a displacement other than by folding.

On Morris creek there is an apparent trough, but at the point of reversal of dip, which should be the centre of the trough, the beds on the east belong to a place at least 1,200 feet higher in the section than those on the west. There is here probably a break in the western limb and a push up of the block on the west; the amount of displacement, though depending on the unascertained dip of the fault plane, was evidently greater than 1,200 feet.

The surface drainage north of Morris creek runs to the Athabaska, and the exposures are below those of Morris creek. The only exposure there, along the eastern edge of the western block, occurs on Mountain creek, quite near the probable line of break, and shows sandstones, containing a 9 foot coal seam, lying almost horizontal, and evidently, from the attitude of neighbouring beds, forming the centre of a syncline. Near the Athabaska the eastern block is traced only by the sandstone ridges of its eastern margin, and the structure is concealed. Gravel terraces along the sides of the Athabaska valley mask all the outcrops on the lower slopes, and prospecting is limited to points 280 feet above the river.

North of the Athabaska the break that separates these two blocks is shifted to the east, and the eastern trough is very much compressed, and probably disappears as a coal field. Mineable areas on this eastern trough are probably confined to the block between Morris creek and the Athabaska. The western block appears to present no serious folding or faulting in the lower part of the coal measures. As the beds in the two blocks are of the same series, there is a repetition in them of the same beds, and the location of a coal seam in one should prove a help towards the discovery of the corresponding seam in the other.

COAL SEAMS FOUND IN WESTERN BLOCK.

Villeneuve Creek.—The lower shales and sandstones of the Kootanie appear by the sections on this creek to contain very little coal, thin streaks only being observed from the bottom sandstone up to near the conglomerate bed. Some coal dust, occurring below this conglomerate, may indicate a small seam, but its thickness can not be very great. Above the conglomerate the beds show the following section:—

Sandstones.	Feet.	——
Coal, over	10	
Sandstones	250	
Coal	12	Sample and analysis.
Sandstones	350	
Streaks of coal	.. .	
Sandstones	100	
Coal	5	
Sandstones	250	
Conglomerate	30	
Coal dust	......	

Morris Creek.—On Morris creek, the first western branch of Fiddle creek, the following section is given, but it is only approximate, the distance being estimated by pacing.

Sandstones	heavy bed.	
Coal	3 feet 10 inches.	Coal, 10 feet 11 inches. Sample and analysis.
Shale	6 "	
Coal	7 " 1 "	
Sandstone	150 " 0 "	
Sandstone and shale	100 " 0 "	
Coal	9 " 7 "	
Sandstones	350 " 0 "	
Coal	5 " 6 "	Coal, 8 feet 6 inches.
Sandstone	2 " 0 "	
Coal	3 " 0 "	
Sandstones and shales	300 " 0 "	
Conglomerate		

NORTH OF MORRIS CREEK.

Below where several streams, coming from the east face of Roche Miette, unite to form a brook, locally called Mountain creek, an exposure of a seam in a shallow syncline shows 9 feet of coal. This may be in the bent-over eastern edge of the western block, since, farther north, a seam of the same thickness outcrops along the face of the sandstone ridge to the west. In the gorge, west of this, in more regular beds dipping 42° southwest, a 5 foot 7 inch seam has been uncovered. Neither of these seams has been traced by the prospectors towards the Athabaska, but the sandstone ridge between them is prominent, and runs to the edge of the valley, where it sinks beneath the gravel terrace. On its eastern flank, a 9 foot seam was followed by trenching about a mile, to a point about 1,500 feet from the edge of the terrace, and farther, by pits in the gravel; then by an open-cut and a covered roadway 500 feet long from the edge of the terrace at the level of the seam, an entry was made on the coal seam.

The surface slope along the ridge is to the north, and from Mountain creek to near the tunnel entry it is gradual, but steepens near the Athabaska. From the point at which it meets the sloping surface of the terrace, the outcrop dips very gently, so that the tunnel will have light cover for perhaps 1,000 feet from the entry. Beyond that point the cover will be sufficient to ensure the coal being below the zone of surface weathering, and the coal will be high enough above the entry for economical mining.

The seam dips 56° to the southwest, and is here about 500 feet, horizontally, west of the conglomerate outcrop. This is a distance through the beds of about 414 feet. The section of the seam at the tunnel is:—

Coal	9 feet 6 inches.
Sandstone	2 " 0 "
Coal	3 " 0 "

From this entry it is proposed to cross-cut the measures to the west, to reach another seam, whose outcrop has been located, 1,050 feet from the tunnel. The latter seam is a good coal, and has a thickness there of 13 feet. It is an upper seam, and, measured by the dip of the beds, is about 870 feet above the tunnel seam.

It is probable that other seams that are indicated in the sections on Morris and Villeneuve creeks may also occur here; if this is found to be so it will add materially to the value of the mine.

NORTH BANK OF THE ATHABASKA.

The exposures along the sides of the valley are largely masked by the old river gravels, in the same manner as to the south, although the terrace is not so well marked. It is partly on account of this drift cover that so few seams have been found near the river.

An opening has been made into a seam, at about the horizon of the tunnel seam, having a thickness of 10 feet 5 inches. The seam is on the slope of a small gully, and the prospect trench in which it was found is high up on the side of the gully, near the surface, and not deep enough to reach the unweathered coal. A small seam has been found about 1,000 feet west of this, which may be near the horizon of the 13 foot seam on the south side of the river, and another is reported, about 3 miles north, occurring below the conglomerate. Prospecting in this area is difficult, owing to the surface covering, so that the resources of the lessees have been withdrawn largely from prospecting, and have been directed towards installing a temporary mining plant on the two seams already found near the railway, on the south side.

EASTERN TROUGH.

The southern limit of the eastern trough, considered from the point of view of its value as a coal mining area, will be found to be between Morris and Villeneuve creeks, since, on the latter, only the lower part of the coal bearing beds remains, the bottom of the trough passing probably less than 800 feet below the trench cut by the creek. On Morris creek the trough is much deeper, and the measures, consequently, thicker, so that the coal seams near the conglomerate, although probably folded at the bottom of the trough or near the fault line, may prove of value. On this latter creek in the same trough, on the eastern side, a seam was observed, standing at a high angle, with the following section:—

Sandstone roof—	
Shale..	1 foot 5 inches.
Coal	1 " 2 "
Shale	1 " 7 "
Coal	1 " 0 "
Stone	0 " 2 "
Coal	3 feet 6 "
Yellow clay	1 foot 2 "
Coal	0 " 8 "
Yellow clay	0 " 7 "
Coal	1 " 7 "
	13 feet 6 inches.

On the western side a small seam dipping east was noted, but it did not appear important. Northwest to the Athabaska there are exposures of the sandstones, and of the conglomerate ridge of the eastern edge of this trough only, so that no estimate of its depth could be formed. One coal seam has been found having 5 feet 3 inches of coal. This is on a small eastern branch of the stream, that cuts through the terrace at the collieries.

Character of the Coal.—The coals of this district show the effects of surface weathering probably more than in the fields to the south. Some analyses from outcrops on hillsides, where erosion by stream action is absent, give results that would indicate very soft coals, that is, with high volatile hydrocarbon percentages, and a potash reaction similar to that of lignites. That this is due to weathering is shown by the following analyses:—

The first sample is from the bottom of a shaft 30 feet below the surface and at the top of the hard coal. The second is from the same seam farther up the hillside, where the seam is reduced to black powder and noticeably filled with surface dirt.

Tunnell Seam, Jasper Park Collieries.—Lump Coal from Upper Part.

—		Recalculated for	
		Clean Coal.	Dry and clean.
Moisture	0·99	1·03	....
Volatile	20·46	21·32	21·34
Fixed carbon	74·52	77·65	78·46
Ash	4·03	....	....
	100·00	100·00	100·00

Tunnel Seam at Prospect Hole near Surface.

—		Recalculated for	
		Clean Coal.	Clean and dry Coal.
Moisture	5·83	7·89	....
Volatile	21·33	28·87	31·34
Fixed carbon	46·73	63·25	68·66
Ash	26·11	....	....
	100·00	100·00	100·00

The recalculation is made to facilitate a comparison of the coals in the two examples. The weathered coal in many of these exposures, while showing very little fracturing due to lateral movement, is so fissured that it contains a large amount of water, and crumbles readily in the hand. Its finely fractured appearance seems to be largely due to the action of frost, and this agency may have also aided in the oxidation of the coal.

The exposures in Morris and Villeneuve creeks are of somewhat fresher coal, since the scouring action of the stream removes a small portion of the surface of the seam each season.

The sample taken from a similar seam on Villeneuve creek, generally supposed to be the Tunnel seam, gives the following analysis, according to Mr. Wait:—

Sample across Seam.

—		Recalculated for	
		Clean.	Clean and dry.
Moisture	2·37	2·54	....
Volatile	22·38	23·98	24·60
Fixed carbon	68·58	73·48	75·40
Ash	6·67	....	....
	100·00	100·00	100 00

Sample from opening on 10 foot 5 inch seam, north bank of Athabaska, supposed to be the same as Tunnel seam.

Analysis by Mr. Wait:—

—	Recalculated for		
		Clean.	Clean and dry.
Moisture	3·52	3·77	......
Volatile	21·42	22·99	23·89
Fixed carbon	68·22	73·23	76·10
Ash	6·84	......	......
	100·00	100·00	100·00

Upper Seams.—The correlation of the seams at the collieries with those on the creeks is difficult, so that the following analyses, although they appear to be very similar in character, may be from different seams.

Analysis by F. G. Wait of coal from 13 foot seam west of Tunnel seam at collieries. Sample from lump coal on dump, hole full of water:—

—	Recalculated for		
		Clean Coal.	Clean and dry Coal.
Moisture	1·05	1·08	......
Volatile	24·68	25·51	25·79
Fixed carbon	71·02	73·41	74·21
Ash	3·25	......	......
	100·00	100·00	100·00

Sample across upper seam on Morris creek, coal 10 feet 11 inches. Analysis by F. G. Wait:—

—	Recalculated for		
		Clean Coal.	Clean and dry Coal.
Moisture	1·34	1·44	......
Volatile	22·91	24·70	25·06
Fixed carbon	68·51	73·86	74·94
Ash	7·24	......	......
	100·00	100·00	100·00

These both appear to be coking coals. Part of the seam at the tunnel cokes in the laboratory.

A sample was taken across the 5 foot 2 inch seam in the eastern basin, east of the collieries. It showed, on analyses, the same character as in the weathered sample

from near the mine, that is, high volatile hydrocarbon and high ash. The comparison with the hard coal in the tunnel seam shows the futility of using these analyses of weathered material to show the character of the coal beneath.

Coking Qualities.—The samples which were taken from the parts of the seams which appear to be least affected by weathering show that all the seams are probably bituminous, but approaching the anthracitic, that is, comparing them with other known coals, they probably are somewhat harder than the Crowsnest coals and the coals of the Brazeau field, but softer than the Canmore steam coals.

It is not certain that the lower seams will prove to be coking coals. A seam below the conglomerate north of the Athabaska, from an analysis furnished by the Collieries Company, is, probably, similar to the Canmore coal, and, therefore, probably too high in fixed carbon to coke.

The seam in the tunnel at the collieries has possibly been mined far enough to give unweathered coal, but the sample taken in September, 1910, was from near the surface, and shows that part of the coal will coke. None of the other samples from natural outcrops of this seam near the surface give a hard coke. In the case of the upper seam, even when it is judged from samples, possibly weathered, there appears to be no doubt of its coking properties. Thus, in mining the coal from these two seams, there is a probability that the fine coal produced may be utilized to make coke of a high grade.

DEVELOPMENT WORK.

Before the completion of the railway much of the development work was necessarily of a temporary nature. Log houses for the men and officers, and other temporary buildings, were erected; and the mining consisted principally in sinking pits on the outcrop of the seam, and the commencement of a tunnel. The plan temporarily adopted for mining was by level entry along the strike of the coal; starting from the edge of the terrace an open-cut was made through gravel, followed by a covered way, partly in gravel and partly in rock or coal, carried to a point where the tunnel was altogether in coal.

The edge of the terrace is about 270 feet above the grade of the Grand Trunk Pacific railway at this point, so that the mine cars will be lowered down the slope to a temporary tipple.

The dip of the seam, which appears to be 56°, will be tested by slopes, and a permanent entry will then be constructed from the face of the gravel terrace, at an elevation of 30 or 40 feet above the railway. The temporary tunnel will then be used as a return air way.

HOT SPRINGS.

About 1¾ miles up Sulphur creek, at the centre of a broken anticline, in which the limestones are standing at a high angle, great boulders of travertine are seen in the bed of the creek, and on the hillside to the north. These show that the springs, which deposited the material of which they are made, issued from points above the present surface. On account of the denudation of the gorge the springs are now tapped at a lower level, and issue by several openings, apparently, in the case of the larger spring, through loose fragments. The fissuring through which these springs emerge is confined to a zone possibly 200 feet wide, and as many as six separate springs are to be found, mostly near the bed of the creek, and of differing temperatures from tepid to 120°. The water is charged with gases that give off a smell of sulphur.

A specimen of the water, obtained by officials of the Interior Department, was submitted by them to the chemist at the Experimental Farm. His report shows

that sulphates of lime and magnesia form the larger part of the dissolved solids, and are the materials that are being deposited by the springs.

'*Report on Water from Hot Springs creek, Jasper park, Alberta.*'

'Clear and sparkling, distinctly alkaline reaction. No odour or marked taste.

—	Parts per Million.	Grains per Gallon.
Total solids at 212° F.	1,825	127·75
Loss on ignition	90	6·3
Solids after ignition	1,735	121·45

The solids as obtained by evaporation are white, and there is no charring on ignition. The ignited solids effervesce with dilute acid.

ANALYSIS OF SOLIDS.

—	Parts per Million.	Grains per Gallon.
Silica (SiO_2)	45	3·15
Sulphuric anhydride (SO_3)	902	63·14
Carbon dioxide (CO_2)	85	5·95
Phosphoric acid (P_2O_5)	traces.	traces.
Chlorine (CL)	7	0·49
Oxide of iron (Fe_2O_3) Alumina (Al_2O_3)	none.	none.
Lime (CaO)	558	39·06
Magnesia (MgO)	108	7·56
Potash (K_2O)	21	1·47
Soda (Na_2O)	17	1·19
	1,743	122·01

'In the following table the foregoing are presented combined, and as they probably exist in the water.

—	Parts per Million.	Grains per Gallon.
Sodium chloride (NaCL)	11	0·77
" sulphate (Na_2So_4)	27	1·89
Potassium sulphate (K_2So_4)	39	2·73
Magnesium " ($MgSo_4$)	324	22·68
Calcium " ($CaSo_4$)	1,104	77·28
" carbonate ($CaCo_3$)	193	13·51
" phosphate (Ca_3 (PO_4) 2)	traces.	traces.
Oxide of iron, Alumina ($Fe_2O_3Al_2O_3$)	"	"
Silica (SiO_2)	45	3·15

'Owing to the small quantity of water furnished—about 750 cc.—it was not possible to obtain a sufficiency, in certain of the determinations, for a thoroughly

satisfactory conduct of the work. Among such instances, lithium might be mentioned; no trace of this metal could be detected, but the value of this finding is very considerably affected by the small volume of water available for the test.

'Judged generally, the water appears to be moderately hard, the hardness being "permanent" rather than "temporary"; the chief constituent is sulphate of lime and next in order is sulphate of magnesia, which latter would probably render the water slightly laxative in its effect on the system. Notable amounts of the sulphates of potash and soda are also present.'

(Signed) FRANK T. SHUTT,
Chemist, Dominion Experimental Farm.

Following the same line of faulting southeast there are found several large springs, but none, so far as noted, that could be called hot springs. They are all depositing large quantities of lime and magnesia, and may be found to be of medicinal value.

SASKATCHEWAN RIVER DISTRICT.

(*W. McInnes.*)

The region explored lies just north of the Saskatchewan river, in the eastern part of the Province of Saskatchewan. It includes, in its southern part, a drift-covered area which forms part of the Saskatchewan valley, and in its northern part, the higher land of the Pre-Cambrian plateau, while between lies a comparatively flat or gently tilted upland underlain by Palæozoic sediments.

OBJECT OF EXPLORATION.

The exploration was undertaken for the purpose of fixing the positions of the northern edges of the various sedimentary systems which overlap the Pre-Cambrian; and to gain a better knowledge of a tract of country hitherto unexplored, and lying away from regular routes of travel.

METHODS OF WORK.

Travel through the country was altogether by canoes; a continuous survey was made, with compass and micrometer telescope, from Cumberland House, on Cumberland lake, northward to the eastern end of Wapawekka lake, connecting there with the surveys of 1908, and giving a tie line between Stanley, on Churchill river, and Cumberland, on the Saskatchewan; an offset was also run to Pelican narrows. Surveys in detail were made of all the lakes along the route, including Ballantyne lake, an open body of water upwards of 150 square miles in area, connected by a narrows with Deschambault lake. Track surveys were made of Torch and Oskikibuk rivers, and of a part of Amisk lake.

Mr. W. B. Wiegand acted as assistant in the micrometer work.

GENERAL DESCRIPTION.

The southern portion of the area forms part of the easterly-trending, broad valley of the Saskatchewan river, and is about 900 feet above sea-level. It is very imperfectly drained by the river, which, in periods of flood, overflows its banks and spreads over nearly all of this low lying land.

From the northern edge of the valley, the land underlain by the Palæozoic sediments gradually rises northerly, and reaches, at the northern rim of the sediments, a height of about 1,100 feet above the sea, while beyond, to the northwest, the Pre-Cambrian plateau, in places, is 1,200 feet or more above the sea.

The low, flat country forms a broad belt along this part of the Saskatchewan river, extending northerly from the river for 15 miles, and southerly for 25 miles to the base of the Paskwia hills. Through it the river flows easterly, with everywhere a strong current, and along certain stretches a very rapid one, which, in places, where trains of boulders from the till cross the channel, forms heavy rapids. Many islands divide the current into various channels.

About forty years ago, at a point 33 miles above Cumberland House, the river broke through the 2 mile wide barrier of low land separating it on the north from the channel of Torch river, a large stream draining Candle lake, and flowing, in a course roughly parallel with the Saskatchewan, into Cumberland lake. The break occurred

during the period of the spring flood, the water following the course of an old canoe portage leading from one of the sharp northerly bends of the Saskatchewan to a southerly elbow of Torch river.

At first a small stream, the overflow has yearly increased in volume by wearing away its banks, until now, at low water, the old Saskatchewan channel carries but little water, and vessels of all kinds, even flat bottomed scows, follow the new channel. The great increase in the volume of water now flowing in what was Torch river has caused the stream to break through its banks in many places, and to carve out new channels through the low land, so that now the water follows many meandering courses, which reach Cumberland lake through mouths situated at various points along 12 miles of its southern shore. Even after reaching the lake the water keeps to a river-like channel, skirting the northern shore and separated from the lake by long, narrow, wooded islands that form an almost continuous barrier, the gaps between them being few and narrow. The water rejoins the old channel of the Saskatchewan by the Bigstone and Tearing rivers, the two old outlets of Cumberland lake, now, however, augmented by the increased volume of water into rivers with broader and deeper channels than formerly. The water of the Saskatchewan always carries a large amount of suspended, silty matter, and, from the greater abrasion along the new channels, pours into Cumberland lake a still more murky flood. The sedimentation due to this, together with the wearing down of the outlet channels by the increased flow of water through them, has already made the lake so shallow as to be navigable, in low water, only through tortuous channels leading to the two outlets.

The drainage of the whole of the area travelled is into the Saskatchewan river; the eastern and western parts directly, by streams flowing southerly and easterly to Cumberland lake, and the northwestern section by streams that run first northeasterly to Deschambault lake, and then, by a horseshoe curve at Mirond lake, southerly into Cumberland lake.

All the rivers have swift currents, and their courses are broken by many rapids and occasional falls.

CLIMATE.

The climate is much like that of the cultivated portion of northern Manitoba, though the higher latitude makes the hours of sunlight longer in summer and shorter in winter.

The winters, though long and cold, are not so severe as might be expected. It was rather surprising to find among the Indians on Deschambault lake, young cattle in excellent condition, that had wintered out protected only by a string of dog bells to frighten the timber wolves. The summers are warm enough to ensure the ripening, in an average season, of all common grain crops.

No systematic farming is carried on anywhere in the district, though around the Hudson's Bay Company's posts at Cumberland and Pelican Narrows, the Company officers cultivate successfully all the common garden vegetables, including tomatoes and Indian corn, and the Indians grow potatoes at many places throughout the district.

FAUNA AND FLORA.

Moose are found everywhere in the area, and, if not actually increasing in numbers, are at least holding their own. They are particularly plentiful in the low lands north of the Saskatchewan, where, in the slightly higher western region, wapiti and jumping deer are also found, though less plentifully.

The ordinary fur-bearing animals of this latitude are still fairly numerous, except beaver and otter, both of which have been nearly trapped out.

There are areas still standing of good white spruce, both in the region of the Saskatchewan valley, and in the higher land to the north, though forest fires have denuded much of the region of what valuable timber it once supported. Several tracts of considerable size were burnt over last summer. Could the fires be prevented or checked, large areas would within a measurable period become reforested, since the rate of growth in favourable situations is fairly rapid. Two white spruces growing in Cumberland lake were cut into for the purpose of ascertaining their rates of annual growth. It was found that the added growths for the past three years, deduced from the rings of growth, were three-fourths of an inch and half an inch respectively, rates that compare favourably with those of many a much more southerly locality.

MEANS OF ACCESS.

Access to the country is had by the Saskatchewan river, which has been the highway of travel since the region was first visited by Europeans more than a century ago. For years the fur trading companies carried their supplies in north canoes and York boats, by this route. Subsequently river steamboats of high power and low draught were used on the river, but after railways gave access to the upper reaches of the river, the boat service was largely discontinued, until now no general passenger or freight service is maintained.

A branch of the Canadian Northern railway is open to the Pas mission on the right bank of the river, and a bridge is now being built for its extension northward to Hudson bay. It is under contemplation also to improve the channel of the river, and surveys were being made by the Public Works Department during the summer, with the object of ascertaining what could best be done in this direction and at what cost. With the completion of the railways now under way, the contemplated improvement of the channel will make all parts of this great valley easily accessible.

The northern part of the area, beyond the Saskatchewan valley, must still be reached by canoes or York boats, owing to the small volume and steep grades of the streams.

GENERAL GEOLOGY.

The northern part of the region explored is underlain by part of the great complex of Pre-Cambrian rocks that forms the Canadian shield. These Pre-Cambrian rocks are overlapped by Palæozoic sediments coming in from the south, the northern edge of the overlap presenting a most irregular line due to unequal erosion, but running in a general east and west direction. It is thought that the heavy cover of drift conceals in the southwestern parts of the area, undenuded remnants of lower Cretaceous beds, probably including sediments of both Benton and Dakota age.

Evidence of a general glaciation of the region is everywhere present. Erratics are common, and striated surfaces plentiful. The general course of the striæ is a little east of south, indicating that the ice sheet which left these records had its source in the Keewatin rather than the Labradorean centre of dispersion.

TABLE OF FORMATIONS.

Quaternary	Recent, fluviatile, and lacustrine deposits.
	Post glacial lacustrine clays.
	Glacial boulder clays.
Cretaceous	Benton shales.
	Dakota sandstones (not exposed).
Devonian	Magnesian limestones (not exposed).
Silurian	Niagara magnesian limestones.
Ordovician	Galena-Trenton sandstone and magnesian limestones.
Pre-Cambrian	Laurentian and Keewatin biotite gneisses, hornblende gneisse and schists, diorites, etc.
Igneous	Granites and pegmatites.

QUATERNARY.

The Saskatchewan river and, to a smaller degree, its tributary streams, have, since the close of glacial time, deposited large amounts of transported material, largely taken from one part of the area and redeposited in another, but partly brought from outside the area. The process is still going on actively, and the effects are very plainly seen in the region of Cumberland lake and its vicinity, where the river is now depositing material very much as over a delta plain.

Areas of clay about the central part of the region, from their character seem to be the result of sedimentation in lakes bordering the retreating ice sheet of glacial time.

Glacial boulder clay occurs as erosion remnants here and there throughout the area; these probably represent parts of a once extensive sheet that spread widely over the low land now forming the Saskatchewan valley.

Erratics, ice borne from the northwest, are scattered everywhere over the district; many dropped by the ice in their present positions, and many washed by later erosion from the boulder clay.

CRETACEOUS.

No Cretaceous rocks were seen during the exploration. Mr. J. B. Tyrrell, however, informs me, in a personal letter, that at a low stage of water in the Saskatchewan, he found in the river bed along the stretch between the Tobin rapids and Birch islands, shales that he was able to recognize as of Benton age.

On Carrot river, to the south, and on the shores of Wapawekka lake, to the northwest, Dakota sandstones are exposed, and it may be inferred that, in the intervening area also, they form the lowest beds of the Cretaceous, underlying the drift cover.

DEVONIAN.

It is probable that Devonian rocks which protrude from beneath the Cretaceous cover, both east and west of this area, also occur in the same position within the area, though no exposures that were recognized as of that age were seen, owing probably to the great thickness of the drift in the part of the region where they might be looked for.

SILURIAN.

Silurian beds, consisting of white-weathering, brown-buff, magnesian limestone, are the highest Palæozoic rocks exposed. They overlie, conformably so far as can be seen, the Ordovician, and are made up of white-weathering, brown-buff, hard, somewhat crystalline, magnesian limestone, which forms a gently undulating sheet extending over the southern part of the area. Exposures were seen at a few points only, on Cumberland lake, near the northern edge of the Saskatchwan valley. A few very badly preserved fossils, collected from these beds, were examined by Mr. Percy E. Raymond, who was able to identify *Isochilina grandis latimarginata*, Jones, and *Favosites*, with *spiriform septæ*. These, taken in conjunction with the earlier collections of Tyrrell, Dowling, and others, fix the age of the beds quite satisfactorily.

ORDOVICIAN.

The most widely exposed sediments of the region are of Ordovician age, and of about the horizon of the Winnipeg limestone. They occupy a broad belt, directly overlying the Pre-Cambrian complex, and apparently conformably overlain to the south by the succeeding similar beds of the Silurian.

At the base occurs a thickness of 10 feet or more of a very siliceous, friable, white sandstone, made up almost entirely of well rounded, grains of white

quartz, overlain by 6 inches of very soft shaly sandstone; a band a few inches thick of iron carbonate rock; 12 inches of red-purple, mottled, hard calcareous sandstone, and, over all, a cover of brown-buff, hard magnesian limestone, which spreads widely, in gentle undulations, over the central part of the area.

Owing, as in the case of the Silurian, to the crystalline character of the limestone, the fossils collected were few; but they serve, as in the other case, when taken with earlier collections, to fix the age of the containing beds.

Mr. Raymond identified among them: from Deschambault lake, *Platystrophia lynx* (Eichwald), and *Receptaculites Oweni,* Hall; from Bigstone lake, *Receptaculites Oweni,* and a fragment of a large coral; and from Pelican lake, *Clionychia,* sp.

PRE-CAMBRIAN.

The northern part of the area is entirely underlain by Pre-Cambrian rocks. They consist mainly of biotite gneisses, hornblende gneisses, and granodorites, but include two belts of more basic rocks, which, from their lithological characters, may be referred to the Keewatin. One of these belts, where it emerges from beneath the Ordovician limestone at Amisk lake, has a width of about 12 miles. The other, which is exposed near the northwest corner of the area, emerges also from the limestone cover; it is narrower than the first and is lost in the gneisses within a few miles.

INTRUSIVES.

One large area of intrusive red granite, or, more exactly quartz-mica diorite, since most of the feldspars are plagioclase, was recognized as being a continuation of that found, in 1908, along Wapawekka lake. Exposures were seen along Wapawekka river and its tributary lakes and streams. Minor intrusions of granite and pegmatite are common. They cut everything up to the sedimentaries, which are quite undisturbed.

Economic Geology.

Economic interest has been confined to the Keewatin belts, since these seem, from the experience gained in other areas, to afford a more promising field for the work of the prospector than any of the other areas. No part of the area can be said to have been prospected yet, although a few prospectors have made hurried trips through parts of it. Though both the Keewatin belts may be described as not unpromising, the eastern one, from its greater width and extent, is the more attractive. So far as known, no deposits of sufficient value to be worked have yet been found.

Limestones which, though magnesian, are well suited for burning commercially for lime are plentiful over all the area, except the extreme northern part. Many of the beds of limestone are also well situated for quarrying, and adapted for building stones.

CLAY AND SHALE DEPOSITS OF WESTERN CANADA.

(Heinrich Ries.)

During the summer of 1910 the writer was in the field for a period of somewhat over three months, engaged in a study of the more important clay and shale deposits of the western provinces. He was aided throughout in the work by Mr. Joseph Keele, of the Geological Survey, but previous to my taking the field, Mr. Keele spent several weeks alone in Manitoba, and the results of his work in that Province are reported on separately.

The field work was begun at Winnipeg, Man., and extended westword as far as Victoria, B.C., but the present summary covers the territory between Regina and the coast.

Samples were collected from many localities, for the purpose of testing, but as the laboratory investigation of these is not yet complete, only the mode of occurrence of the clays and shales, and the industry based thereon, is referred to.

With reference to the geographic distribution of the clays and shales, it may be pointed out that the most extensive and important deposits lie east of the Cordilleran area, in other words, in the region of the Great Plains; while second in extent are the deposits of the Pacific coast belt.

Few or none are found in the region lying between the eastern boundary of the Rocky mountains and the Coast ranges.

Geologically, the clays and shales show a somewhat restricted distribution, ranging from Jurassic to Pleistocene.

For convenience of description the occurrences may be divided into three areas, viz., the Great Plains, the Cordilleran, and the Pacific coast.

GREAT PLAINS REGION.

In that portion of the Great Plains area lying west of the longitude of Regina and Prince Albert, surface clays and silts are abundantly distributed, and often used locally for the manufacture of common brick. The product thus made is usually of red colour, and often highly porous, but since in many districts no other material is locally available, it has to be used. Those clays which are strongly calcareous yield a buff brick.

The Pleistocene clays and silts referred to above are in most cases glacial deposits, some of them containing small pebbles, at times of calcareous character. They are worked around Regina, Saskatoon, Prince Albert, Moosejaw, Medicine Hat, Red Deer, Cochrane, and otther places of minor importance.

At some points, as Edmonton, flood plain deposits are extensively employed for making common and pressed brick. In most cases, however, the surface clays are not adapted to pressed brick manufacture.

There are certain areas, some of them rather extensive, that are underlain by clays and shales of Tertiary or Cretaceous age, which hold out strong promise for the future, and whose prospective value has been, in part at least, realized, even at the present time. I refer to the areas around Dirt hills, Souris valley, Medicine Hat, Edmonton, and Calgary.

Dirt Hills Area.—This name is applied to a group of hills rising from the plains about 30 miles south of Moosejaw, and extending south and southeastward for some distance. The beds are of Laramie age; and about 23 miles south of Drinkwater, on

the Portal branch of the Canadian Pacific railway, there are exposed a series of white and brown clays in the outer slopes of the Dirt hills. The beds appear to dip westward, and the hills in which the clays occur have a steep eastern face, and a western slope conformable to the dip.

The predominant beds are white and greyish white sandy clays, and brownish red siliceous clay shales, as well as some gypsiferous beds and bluish clays. The white sandy beds, which form the larger part of three hills, are quite prominent, and contain occasional lenses of a finer grained white clay.

The succession of beds, from the bottom up, where the white clays are best exposed, appears to be as follows:—

Brownish clay-shales.
Soft sandstone.
Grey clay.
White sandy clay.
Thin beds of purplish and bluish shale.
Brownish clay-shales.
White and grey clays.

The white clays are fireclays, fusing at cones 30 to 32.

Some of the white sandy clay has been hauled to Moosejaw and made into boiler setting brick, with good results.

The practical development of these clays hinges upon a satisfactory solution of the transportation problem, and this may occur at no distant date, as there is said to be a projected branch of the Canadian Northern, which will pass within 3 miles of these clay deposits.

Souris Valley.—The lignite seams of the Souris coal field have been described by Dowling[1], and in his paper mention is made of the sandstones and shales which are interbedded with the lignites. There seems little doubt that many of these shales could be utilized for the manufacture of clay products, but up to the present time not much has been done to develop them.

The only locality at which they are worked, is at Estevan, Sask., where the shales belonging to the upper member of the coal series in that field are mined by the Estevan Coal and Brick Company.

The section shown in their workings is as follows:—

Top glacial clay	10 to 20	feet
Lignite	8	"
Parting clay shale	2 to 2½	"
Lignite	8 in. to 2	"
Blue clay shale, upper 15 feet smooth	30 to 40	"

The top clay, which is highly calcareous and cream burning, is used for making common brick.

The shale, which is won by drift mining, is used for making dry-pressed brick. It is red burning.

Shales are found at a number of other points in the Souris River coal field, but some of them crack in air drying. One very smooth plastic deposit was found overlying the clay at Pinto.

Medicine Hat.—This town lies in the Belly River shale area, the beds of this formation being exposed at a number of points along the Saskatchewan river, as well as in the slopes of some of the surrounding hills, where the shales have not been removed by pre-glacial erosion, or are not covered by glacial clays or silts.

It may be said of the shales of this area in general, that they consist of more or less lenticular bodies of clay shales, and shales which are sometimes separated by lenses of sandstone.

[1] Can. Geol. Survey, Annual Report, Vol. XV, Pt. F.

The lenticular character of the beds is proven by the fact that their structural relations can sometimes be well seen in one excavation, and also because sections on opposite sides of the river may be totally unlike so far as regards the beds over and underlying the same coal seams.

The shales show a variety of colours, and range from highly silicious to those of very fine grain. Some of the beds evidently contain a large amount of colloidal material, and have to be dried very slowly to prevent cracking, but this cannot always be avoided. Some of them may be cured of cracking by pre-heating, and experiments are now under way to determine this.

Most of the shales of the Medicine Hat region are not refractory, and only one of the beds thus far opened up is claimed to be a good fireclay.

The Belly River shales are now worked near Coleridge and Red Cliff. At the former locality the shales outcrop on the slope of a steep ridge, and are said to have been tested by 80 foot borings. The beds show the usual lenticular arrangement, and since the lenses vary in character, and are interbedded in places with sandstone, some selective mining and sorting is necessary. Among the types of clay thus far identified here by the owners are, sewer-pipe, pressed-brick, and fireclay.

The shales are loaded on cars, which are run down a spur to the Canadian Pacific railway, and thence to Medicine Hat, where they are to be used at the new and extensive plant of the Alberta Clay Products Company.

At Red Cliff, 6 miles up the Saskatchewan river from Medicine Hat, a somewhat deep section is exposed in a coulée running from the top of the cliff down to the river level. The shale bank has been opened up about half way down the coulée, and the section is somewhat as follows:—

Shales with sandstones	50 feet
Dark, chocolate clay, checks in drying	3
Alternating shales, silts, and some lignite seams	30
Lignite	5
Sandy shales	15
Lignite	4–5
Carbonaceous shale	2
To river level (concealed) about	50

The run of the bank is used for making a red, wire-cut brick, while one bed in the upper part of the bank is employed for dry press. All of the shales are red-burning, and it is not likely that any of them are refractory.

The raw material is worked up in the recently established plant of the Red Cliff Brick Company.

Directly across the river is another coulée, showing an equally deep section, but the beds are entirely different, and are mostly very sandy in character.

Edmonton.—There are four possible sources of clay or shale in this area as follows:—

(1.) Flood plain clays, of very silty or even sandy character, underlying the low terrace bordering the Saskatchewan river. This material is used for common and pressed brick.

(2.) Glacial (?) clays of highly plastic character, underlying the upper level terrace on which Strathcona and Edmonton stand.

(3.) Shales underlying many of the coal seams, and usually too thin to be utilized.

(4.) Shales higher up in the section than the coal seams at Edmonton and Strathcona.

The last named appear to represent the best type of material found in the immediate vicinity of Edmonton. The best observed exposures lie just northeast of Strathcona, in the valley of Mill creek, and along the Edmonton, Yukon, and Pacific railway. They are exceedingly plastic, and are said to burn to a vitrified body. No

claim is made for a high refractoriness, and some of them have a rather high air shrinkage. This horizon should be carefully prospected to determine the occurrence of clays at other localities.

The development of the clays around Edmonton is a matter of the highest commercial importance, as the demand there for all grades of structural clay products is large.

South of Edmonton, between that point and Calgary, Tertiary shales are found outcropping along the Red Deer river, near the town of Red Deer. Some of these weather to a very plastic clay, but they are not utilized.

Calgary.—The Cretaceous shales are the most important clay resources of this district. They evidently underlie a considerable area, but at most points the outcrops have been obscured by glacial drift. The shales have, however, been opened up for working at two localities. One of these is at Sandstone, and the other about 5 miles west of Calgary. At both points the bank shows massive layers of grey and buff shale, interbedded with beds of sandstone up to 2 and 3 feet in thickness. The latter have to be rejected in quarrying.

Although the shales contain sufficient lime carbonate to effervesce briskly with acid, there is not sufficient to destroy the red burning character of the material. It is used at both localities for making dry pressed brick.

At Cochrane, west of Calgary, there are somewhat extensive exposures of shale, some of which are free from the sandstone beds, so abundant at the two localities mentioned above.

Other Localities.—The Belly River shales are well exposed along the Belly river at Lethbridge, and also in the workings of the coal mines there. Those associated with the coal are often highly carbonaceous, and often gritty, but some, such as those exposed along the wagon road near the bridge across the river, work up to a very plastic mass, even though they appear rather unpromising in the outcrop.

There are also abundant shale beds from 2 to 6 or 8 feet in thickness, interstratified with Cretaceous sandstones, in the low foothills west of Lundbreck. They are best seen in the railway cuts between that town and Hillcrest. Their value and character cannot be definitely stated until the tests on them are completed.

A somewhat important shale bed overlies the coal along the south fork of the Oldman river, 6 miles northwest of Pincher creek, and other Cretaceous clays outcrop in the creek bank on the western edge of the town, as well as several miles to the southwest along Mill creek.

Cretaceous shales, of gritty character, have also been quarried at Seebe siding, east of Kananaskis. Eastward from there along the Bow river, Cretaceous outcrops are frequent, and the entire section should be carefully searched.

CORDILLERAN REGION.

The occurrence of extensive clay deposits was not expected in this region, but nevertheless all reasonable precautions were taken to search for them.

In the Crowsnest Pass district, the Fernie shales have been utilized at Blairmore for making a red, dry-pressed brick, of good quality. Similar shales occur at Coleman.

Shales are associated with the coal seams at Canmore and Bankhead, but are not adapted to brick manufacture.

Flood plain and glacial clay deposits of small extent occur in many of the valleys, and are worked at several localities, including Nelson, Castlegar Junction, Kamloops, and Enderby.

A deposit of colluvial clay, derived from the phyllites on the slopes of Mount Stephen, is found at Field, and a fine-grained plastic clay, suitable for earthenware, occurs in the Yoho valley.

From the few preceding paragraphs it will be seen that no fireclays appear to be known in the Cordilleran region. This is unfortunate, since there are several smelters, and numerous coke ovens in operation, which now have to obtain their supplies of firebrick from the United States and England.

It is hoped that this demand will be supplied in the future by bricks made from the fireclays at Clayburn, or possibly those of the Dirt hills, or even the fireclay (if it proves to be such) at Medicine Hat.

PACIFIC COAST BELT.

The Tertiary beds of Sumas mountain, near Clayburn, contain one of the most interesting series of shales to be found in the western provinces.

The section involves a series of shales, sandstones, and at least one conglomerate. Some quartz porphyry is present, but not in contact with the worked shale deposits.

The entire series appears to dip southwest at an angle of about 15° to 20°, and the shales range from those of a highly refractory character to others of much lower refractoriness. On this account some of the shales burn buff, and others red.

At the base of the section, there appear to be at least two beds of fireclay, the lowest one divisible in some places into three parts. Of these, the lowest bench is called a china-clay, and is said to burn white, but our tests show that it does not. The middle and upper bench are separated by a seam of coal, of variable thickness, and containing flint clay partings. Some of the best fireclay in the mine has a fusing point of cone 32.

These shales are said to be adapted to the manufacture of pressed, paving, and firebrick, and sewer-pipe.

Pleistocene clays are found on the lower slopes of the mountain, and can be used for common brick.

There is now one factory in operation at Clayburn, that of the Clayburn Brick Company. A narrow gauge road has been laid for a distance of 3 miles up a gulch in Sumas mountain, and the total rise in this distance is 450 feet. The mines belonging to the Company are located along the line of this railway.

Other deposits, not yet developed, are found on the opposite side of the mountain, but these will probably be opened up before long.

Around Vancouver, along the Fraser river, at least as far east as New Westminster, and at Sumas mountain, as well as other points, there are deposits of a bluish grey stratified Pleistocene clay, which usually forms lenticular deposits surrounded by coarse sand. The clay is of value for common bricks and is worked at New Westminster, Clayburn, Port Haney, etc.

A glacial clay is employed for common and pressed brick manufacture on Anvil island, in Howe sound. Similar material is also worked on Sidney island, and around Victoria.

Sewer-pipe and fireproofing are made at Victoria from shales obtained near Comox, Vancouver island, and residual fireclay from the northwest end of the same island.

Clay Working Industry.

The main clay working industry at the present time is the manufacture of common brick, but the product in many localities, as around Victoria and Vancouver, does not supply the entire demand, and common brick are imported in large quantities from Seattle, Washington.

Dry-pressed brick are made in small quantities at a number of points, but the only plants of large capacity are those at Medicine Hat and Clayburn.

Most of the pressed brick now used in the western provinces are imported, and command a high market price. The same is true of fireproofing, terra-cotta, fire-bricks, pottery, and sewer-pipe.

It will be seen, therefore, that there is room for abundant development and expansion in the home clayworking industries. The relation of this to tariff questions, which are an influencing factor, will be discussed in more detail in the final report.

OTHER MINERAL DEVELOPMENTS.

It may not be out of place to make brief reference to some of the other mineral developments in the region covered in this summer's work.

In the Crowsnest Pass district, active development is going on in the coal area between Frank and Hillcrest, some of the new mines having reached the shipping stage. The lime rock of the Frank slide is being used for the manufacture of lime.

The Medicine Hat gas field continues to yield steadily, and wells are located as far from Medicine Hat as Red Cliff in one direction, and Dunmore Junction (now Coleridge) in the other, but the limits of the field are not definitely known.

According to Mr. A. K. Grimmer, city engineer of Medicine Hat, about eighteen wells have been drilled at this locality, of which about eight were sunk by the city. Of the latter group three had a depth of 1,000 feet, while the others varied from 300 to 650 feet. The deeper ones show a pressure of about 650 pounds per square inch.

There are three important wells from which the city is drawing its supply, located as follows:—

(1.) Corner Main street and West Allowance: 1,000 feet deep, 4⅝ inch casing, 550 pounds capped pressure; volume 1,000,000 cubic feet per twenty-four hours.

(2.) Corner North River street and Third Avenue: 1,000 feet deep, 6 inch casing, 560 pounds capped pressure; volume, 1,250,000 cubic feet per twenty-four hours.

(3.) On Bridge street, known as Big Chief: 1,000 feet deep, 6 inch casing, 560 pounds capped pressure; volume, 3,000,000 cubic feet per twenty-four hours.

In addition to this the city has four wells to a depth of 700 feet, and the private wells in the city are as follows:—

(1.) Central Canada Packing Company: 750 feet deep, 2 inch casing. This is a wet well, was never in good condition, and is not in use.

(2.) C. Colter, Second avenue: 700 feet deep, 3 inch casing, and 270 pounds pressure when capped.

(3.) C. Colter, Main street: 400 feet deep, 3 inch casing, and 100 pounds pressure when capped. Not in use.

(4.) H. Yuill, South Railway street: 850 feet deep, 4⅝ inch casing, and 270 pounds pressure when capped.

(5.) Canadian Pacific railway: 1,000 feet deep, 6 inch casing, with 2 inch tube and packer. This has a pressure of 560 pounds when capped, and a volume of 1,250,000 cubic feet in twenty-four hours.

(6.) Hargraves well, at end of highway bridge in city; this well is 1,042 feet, has a pressure of 560 pounds when capped, and a discharge of 2,800,000 cubic feet in twenty-four hours.

On May 31, 1910, the city began drilling a well at a point 2 miles east of Medicine Hat, in the N.E. ¼ of N.E. ¼ of sec. 30, tp. 13, R. 5, W. 4th. This well has a diameter of 10 inch casing, and a depth of 937 feet. It was completed August 30, after striking a good flow of gas, with a pressure of 560 pounds at the end of twenty-four hours. A small flow of gas was struck at 550 feet, and continued down to 660 feet.

This well has been turned over to a manufacturing industry, and the gas will be used for blast furnace purposes.

During the summer of 1910 there was a reported discovery of oil at Matsqui, near Vancouver. The facts are these: In digging the foundation for a power-house of a new electric railway, near Clayburn station, a coarse sand containing asphaltic material was discovered, and led to the conclusion that it must represent the hardened seepage from oil-bearing sands. With this idea in view a number of drill holes were put down, none of them to a great depth, and while no flow of oil was struck it is said that some indications were found. Steps have been taken to organize a company and raise money for deeper drilling, and subsequent development if it is warranted.

CLAY RESOURCES OF THE WESTERN PROVINCES.

(*Joseph Keele*).

The investigation of the clay resources of the Dominion, begun last year in the Maritime Provinces, was continued this year in the western provinces. I was again associated with Professor Ries. and accompanied him throughout his stay in the field. Our work was chiefly prospecting for shale and clay deposits suitable for use in the various clay working industries, and also in visiting the localities where brickmaking is now carried on.

Having preceded Professor Ries to the field by about two weeks, this time was occupied in visiting various points in the Province of Manitoba. Owing to the wide scope of the work planned for the summer, only a limited number of localities in each province could be visited. Those in Manitoba were selected with a view to giving a good general idea of the material available in that region. About 20 samples of clays and shales were collected at various worked and unworked localities. The limitations and possibilities of these materials will be fully considered in a report to be issued after the series of tests that are now in progress are completed.

The material available for structural purposes is obtained from two sources—surface clays and shales.

The surface clays, which are usually lake or estuarine deposits, some of which may be of direct glacial origin, are the most widespread. Notwithstanding the fact that these surface deposits are, in many places, of great depth, only a limited portion of them unfortunately can in some localities be utilized by the clay worker. This is the case in the neighbourhood of Winnipeg, where only about 3 feet of the deposit can be used, and although there is often as much as 40 feet of clay of different quality beneath this, it is quite unsuitable for brickmaking purposes. At Brandon the surface deposits consist of stratified sands, silts, and clays, with the sandy and silty layers so much in excess that good hard bricks cannot be produced from them.

At Portage la Prairie, Virden, Hartney, and Gilbert Plains, there are good deposits of clay, which can be worked to as great a depth as the brickyard owners desire. There is only a light covering of soil to be removed, and in places the brick clay comes almost to the grass roots.

The surface clays in Manitoba are nearly all calcareous, the lime content being usually high. The underburned bricks made from them are of a light red colour, and soft and porous; the fully burned bricks are hard, light buff in colour and make a good durable building material.

Shales of Cretaceous age form the bed-rock of most of the western portion of the Province, but on account of the thick mantle of surface deposits, they are not generally seen outcropping. They outcrop plentifully at some localities, however, notably at the Riding, and Pembina mountains, and at two points are worked for brickmaking purposes. The shales, where exposed, are generally hard and non-plastic, so that when finely ground and mixed with water they cannot be moulded into shapes; but in some cases they are decomposed by weathering, and have become quite soft and plastic. The shale used for making dry press brick at Leary siding is in this condition. The shales burn to a red colour, and will stand much harder firing than the surface clays.

About twenty-six brickyards are in operation in Manitoba; of these about four produce dry press bricks, and the rest, with the exception of one stiff mud machine at Alsips yard in Winnipeg, turn out soft mud bricks.

The burning is mostly done in scove kilns, the fuel being generally dry poplar wood, but a few of the more progressive plants have down draft kilns, and burn coal. The season's output varies from 500,000 to 12,000,000 in the various yards, the average length of the season being about 150 days.

The principal difficulties met with by brickmakers using surface clays are: the liability of the green brick to air check while on the drying racks, and in judging the proper degree of burning. Calcareous clays have their points of incipient vitrification and fusion so close together that quantities of the brick near the arches are melted, while the upper layers, which receive the least amount of heat, are underburned and soft, consequently there is great waste. It seems impossible to avoid this in scove kilns, but there is far less waste, and a greater economy of fuel in down draft kilns.

If the clay is mined in the fall, and allowed to weather in a stockpile over winter, subsequent air checking in the drying racks will be considerably reduced, the clay will be easier to work, and it will be available for use earlier in the spring; but only in one instance that came under my notice was this method taken advantage of.

There was a great scarcity of brick in Manitoba during the early part of the building season of 1910. No brick were left over from the season of 1909, and on June 1 there was not a kiln of brick yet burned in the Province. On the night of June 2, about 2,000,000 bricks were frozen on the drying racks, and consequently destroyed.

Common brick usually sell in Winnipeg for $11 per thousand, but this summer they sold as high as $15, and as the local yards were unable to supply the demand large quantities were imported. Most of the pressed brick used for facing buildings is imported.

All the structural hollow ware, and sewer-pipe used in the Province is imported, but the use of paving brick is prohibited by the high freight rates on such a heavy commodity.

I am now carrying on experimental work under the direction of Professor Ries, with mixtures of shales and clays, to find out if it is adapted for a wider range of products than simply common brick.

Special experimental work is also being carried on with the object of devising some practical method of treatment for the underclay at Winnipeg, which may render it available for brickmaking purposes.

A general description of the deposits and works seen in the provinces farther west is given in the summary by Professor Ries, so that it will be unnecessary to repeat it here.

At the close of the season two plants in the United States were visited where deposits are worked similar to certain undeveloped or partially developed deposits in Canada, in order to find out the range of wares that could be manufactured here.

In the vicinity of Seattle, Washington, the clay-working industry is in a flourishing condition, and facing brick, hollow ware, paving brick, sewer-pipe, and glazed terra-cotta are manufactured from material similar to that which occurs so abundantly in Sumas mountain, a short distance east of Vancouver.

At Dickinson, North Dakota, there is a series of clays and shales that appear to be precisely similar to unworked deposits which occur about 25 miles south of Moosejaw, in the Province of Saskatchewan. At the former point a large business is done in firebrick, made by the dry press process, and also in dry press face brick for buildings, and mantels.

GUNFLINT DISTRICT, ONTARIO.

(*J. D. Trueman.*)

Introduction.

A large section of country west of Lake Superior has been examined by the Geological Survey, the results appearing in a uniform series of rectangular maps, on a scale of 4 miles to 1 inch. An area, however, southwest of Port Arthur and Fort William, and extending from Lake Superior west about 75 miles to Gunflint and Saganaga lakes, and from the International Boundary north to about latitude 48° 27', has not yet been included in that series. Intermittently since 1866 silver mining has been active within this district, the best known locality being that of Silver islet, on the shore of Lake Superior. A formation similar to that in which the iron ores of the Mesabi district, Minnesota, occur crosses the area diagonally. Though considerable prospecting has been done in the district, it has not been thorough, and the field still has possibilities for iron and silver discoveries.

Within the area outlined a sketch map[1] of the southeastern portion, as well as a detailed map[2] of a small area about Silver mountain, have been issued by the Geological Survey. During the past summer N. L. Bowen has been engaged in geological work in the eastern part of the district, for the Bureau of Mines, Ontario.

My instructions were to commence the survey of the unmapped area, working east from Gunflint lake. During the summer, examination was made of the country about Gunflint lake, and, to the northeast, about Northern Light, Mowee, and several unnamed lakes in that vicinity. The streams and lakes were surveyed by means of compass and micrometer where absence of local magnetic attraction permitted. Where magnetic attraction was encountered the plane-table and dial compass were used.

Efficient aid was rendered by my assistants, J. A. McKenzie Williams, and R. V. Saunders.

General Character of the District.

TOPOGRAPHY.

A line joining Port Arthur with Gunflint lake would roughly mark the boundary between two sections of country which are distinctly different in topographical character. To the north, as far as examined, in the regular sky-line, and in the rounded hills and numerous lakes, the usual characterictics of vast areas in Canada underlain by Archæan rocks can be recognized. Occasionally glacial drift conceals the underlying relief, but generally the rocks are bare, or covered by a thin mantle of soil supporting a rather heavy forest growth. To the south, erosion of the flat-lying or slightly dipping sedimentary rocks, intruded by diabase sills, has given rise to flat-topped hills, as near Port Arthur, or to sawtooth ridges as around Gunflint lake. The International Boundary is marked by water courses, the eastern section consisting of a chain of lakes flowing into Lake Superior by the Pigeon river. From North lake the water flows west into Gunflint and Saganaga lakes, and then, by numerous streams and lakes, into Rainy lake, and finally Hudson bay.

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[1] No. 285. Thunder Bay Mining Region. Part H, Vol. III.
[2] No. 286. Silver Mountain Mining District, Part H, Vol. III.

TIMBER.

Owing to its rocky character, the value of much of the country near Gunflint lake as a national resource must lie entirely in its mineral and forest wealth. Over considerable areas valuable timber is still standing, the principal varieties of trees being red pine, jack-pine, spruce, balsam, and tamarack. White pine occurs, but is not common. Birch and poplar are quite abundant.

Forest fires during the summer season of 1910 proved unusually destructive over a large section of country west of Lake Superior. A long period of dry weather made conditions very favourable for the spread of fires, so that during the latter half of June, and the earlier part of July, a dense cloud of smoke remained almost continually in the air. While fires were burning in very many places, and immense tracts of forest were consumed, there can be no doubt but that over large areas, where fires existed, the total quantity destroyed was not large.

ACCESS.

The Port Arthur, Duluth, and Western railway, a branch of the Canadian Northern, furnishes the easiest means of access to the district. When lumbering operations were being carried on in the western part of the district by the Pigeon River Lumber Company, service on this line extended to the western end of Gunflint lake. At present trains are not taken beyond North lake, a small settlement maintained largely by the lumber mill of H. Bishop & Co. West and north of North lake there are few inhabitants, and canoes serve as the only means of transportation.

General Geology.

Examination has not yet progressed sufficiently to warrant a full statement concerning the geological history of the region. However, the detailed work conducted over a large area in the adjoining Vermilion district is of much value in interpreting the geological structures present in the Gunflint district, and the general relations of the rocks can be given briefly.

All the rocks of the district are of Pre-Cambrian age. The oldest series, called the Keewatin, consists largely of green schists formed from basic volcanic flows. At some time, possibly when mountain building forces were active, these rocks were intruded by batholithic magmas with the formation of granites and gneisses of Laurentian age. Much later, when the country was worn down to a low relief and the underlying granites were exposed, a sedimentary series called the middle-lower Huronian was laid down. After this the country was again subjected to orogenic movements, later eroded, and again a sedimentary series was deposited. This has been called the Animikie, or upper Huronian. In the immediate vicinity of Gunflint lake the middle-lower Huronian seems absent, so that there is a double unconformity between the Animikie and the older rocks. Since the Animikie sediments were laid down there has only been sufficient disturbance to raise them to their present position and give them the gentle inclination which they now possess. This disturbance probably took place towards the close of Keweenawan times. Except for a narrow band the Animikie sediments have been eroded off the area north of Gunflint and North lakes, and they now lie mostly to the south, with a slight dip away from the outcrops of the older formations.

TABLE OF FORMATIONS.

Pleistocene—

Glacial clay, sand, etc.

Unconformity.

Keweenawan—

Diabase sills and dykes, Duluth gabbro.

Igneous contact.

Upper Huronian (Animikie)—

Slate.

Gunflint iron formation.

Conglomerate.

Unconformity.

Laurentian—

Hornblende granite, hornblende syenite, and diorite.

Biotite granite, biotite granite gneiss.

Igneous contact.

Keewatin—

Greenstone, green schists.

Keewatin.—Though extensively developed in the Vermilion district, and on Hunter island, which lies to the east of the district examined, Keewatin rocks are not abundant in the Gunflint region. Schists of Keewatin age occur in small amount north of Gunflint lake, and greenstones and green schists occupy a larger area north of Saganaga lake. The development of hornblende and chlorite schist in the Keewatin is probably largely due to the presence of the Laurentian intrusives. An intensely folded body of banded magnetite-bearing rock was observed in the Keewatin, north of the northeast arm of Saganaga lake.

Laurentian.—North of the Animikie sediments the rocks are prevailingly granitic or gneissic in character.

Hornblende granite is extensively developed about Saganaga lake. It occupies a large area in Minnesota, and has been given the name of Saganaga granite by the geologists working in that region. On the east shore of Saganaga lake there are almost continuous exposures of this granite. There is a marked uniformity in the general appearance of the outcrops, and undoubtedly they form part of a single batholith. While the rock is typically a hornblende granite, it also contains biotite. Orthoclase and plagioclase both occur. The rock is especially marked by large phenocrysts of quartz and numerous small grains of sphene. Apatite can also be seen abundantly in microscopic sections of the rock. Eastward, between Saganaga and Northern Light lakes, the granite passes, with diminution of quartz, into a hornblende syenite. In addition to the minerals occurring in the granite, the hornblende syenite contains a varying amount of pyroxene, and the rock, at times, approaches a diorite in composition. Occurring as irregular areas in the hornblende syenite and other rocks are masses of hornblende-rich rock or amphibolite. This rock consists of the same minerals as the syenite, except that the ferro-magnesian minerals are more abundant. Part of the hornblende has formed secondarily from pyroxene. The amphibolite varies from a 'pepper and salt' schist to a rock of very coarse, massive character. It is, in places, clearly cut by apophyses or dykes of feldspar-rich hornblende syenite. The amphibolite may, in large part, be extremely altered Keewatin, but, at any rate, the hornblende syenite seems to grade into a rock at least approaching the amphibolite in composition. The hornblende syenite is frequently cut by calcite and quartz veins.

Around Northern Light lake are very extensive areas of biotite granite gneiss. The gneiss is almost invariably fine-grained, and generally white or grey in colour. The banding, though sometimes obscure, is frequently very pronounced. The gneiss cuts and includes masses of the amphibolite, and is clearly of igneous origin. Field

and microscopic observations indicate that the gneissic structure was developed prior to the complete solidification of the rock. In part the banding is due to movements during the consolidation of the rock, but in part also to drawn out inclusions of hornblende schist. This gneiss is thought to be younger than the Saganaga granite, but is provisionally called Laurentian. Around Mowee lake is a rather coarse biotite granite similar in mineralogical character to the biotite gneiss. The rock has been subjected to shearing, as shown clearly by the fractured and drawn out quartz grains.

Animikie.—The Animikie is a sedimentary series dipping gently southeast, away from the exposed areas of Laurentian rocks. It is intruded by sheets of diabase known as the Logan sills. Except for a thin layer of conglomerate, the Gunflint iron formation is the lowest member of the Animikie series. The iron formation is generally siliceous, but varies greatly in character, and is made up largely of ferruginous chert and cherty carbonate. The formation is frequently banded, and shows minor folding. The slate is usually fine-grained, and its thickness is to be measured in thousands of feet. It forms far the greater part of the Animikie series.

Keweenawan.—In addition to sills in the Animikie sediments there are a few dykes of probably the same age cutting the hornblende syenite. The characteristic rock of these bodies is a black to green, medium grained diabase. Phenocrysts of feldspar are frequently present, sometimes of large size. Near the contact the texture is very fine.

Pleistocene.—Glacial drift does not occur in any quantity in the vicinity of North and Gunflint lakes, or northward until some distance beyond Northern Light lake. To the east of North lake there are considerable areas of drift, and agriculture is carried on in the valleys.

Malignite.—During the course of the summer the writer had occasion to visit Pooh-bah lake, the locality where malignite was found, which was originally described by A. C. Lawson. Although boulders of rock similar in appearance to malignite were frequently noticed in the Gunflint district, no outcrops were seen.

While in Port Arthur a block of porphyritic rock resembling malignite was noticed on exhibition. A thin section made from a specimen of this rock shows that it contains ægirine-augite, and a soda-rich amphibole, possibly katoforite, and so should probably be classed as a variety of malignite. The rock is handsome, when polished, and it is hoped that it can be used as an ornamental stone. The quarry, which is the property of the Egyptian Porphyry Co., of Port Arthur, is situated between Beck and McKenzie stations on the Canadian Pacific, about 12 miles east of Port Arthur.

Economic Geology.

Iron.—The possibility of finding iron ore in the district under examination seems limited to two geological horizons—the Keewatin, and Animikie.

Exposures of iron ore formation belonging to the Keewatin have been observed at many points in the Lake Superior region. Generally the rock consists of banded chert and magnetite, or hematite, and the formation is usually associated with Keewatin greenstones or schists. At a few places, as in the Vermilion district, at Michipicoten, and elsewhere, concentration of iron oxide has taken place on a sufficient scale to form an economic deposit. On Hunter island, which lies to the west of the Gunflint region, there has been considerable exploration of exposures of iron formation, but no important bodies of ore have yet been revealed. It was hoped that large areas of Keewatin would be found in the district examined, with the possibility of the occurrence of iron ore, but so far the bands found have been of limited extent. North of the northeast arm of Saganaga lake an intensely folded, banded, magnetite-

bearing rock was observed. The deposit does not seem to be extensive, and in addition to a large percentage of quartz considerable amounts of garnet and epidote are associated with the magnetite.

The Animikie offers, perhaps, a more promising field for exploration for iron than the Keewatin, and is exposed over a large area. It is of much the same character as, and is indeed a continuation of, the formation which in the Mesabi district, Minnesota, has yielded enormous quantities of high grade ore. In the vicinity of Gunflint and North lakes it consists largely of cherty iron carbonate, banded occasionally with pure chert, and more massive ferruginous chert. The latter, as exposed on the north shore of North lake, was probably in large part originally greenalite, a silicate of iron commonly occurring in minute granules. It is here characterized by nodules of siderite, which weather out on the rock surfaces leaving cavities half filled with limonite. Exploration of the formation requires the use of diamond drills, and has so far not been carried out in a thorough manner. Perhaps the most extensive exploration has been made at what is called Paulson's mine, near the western end of Gunflint lake, on the Minnesota side. Here the iron formation has been greatly altered by the Duluth gabbro, with the formation of an amphibolitic magnetite rock. This is extremely resistant to weathering, the process by which bodies of iron ore are commonly formed. The gabbro does not, however, reach the shore of Gunflint lake, so that between the iron formation on the north shore of Gunflint lake, or to the east, and the gabbro, there is a considerable thickness of slate. There are, however, diabase sills in the Animikie, but the exact effect of these on the iron formation is not yet known. The iron-bearing rocks are not as metamorphosed as those to the southwest, and there seems a reasonable possibility of finding iron in economic quantities. East of Port Arthur, indeed, rather thin beds of ore have already been found at several places.

Silver.—Veins of calcite and quartz containing silver, either in the native form or as argentite, and cutting the rocks of the Animikie series, or the diabase sills, have attracted much attention west of Lake Superior, since 1866. The first veins discovered were on the shore of the lake, Silver islet being the most famous mine. Discoveries were later made farther inland, at Rabbit mountain, in 1882, and still later at Silver mountain. Some of the veins proved extremely rich, but many were unproductive. They were all associated with the Keweenawan trap, and in all probability owe their origin to heated waters liberated on the cooling of the diabase magma. Though considerable prospecting was done when the silver camps first opened, it cannot be said that the possibility of further discoveries has been exhausted.

While prospecting for silver-bearing veins was being carried on, claims were staked on some of the calcite veins occurring in the hornblende syenite of Northern Light lake. It is said that silver was found in one of these veins, but this could not be confirmed. Traces of galena and pyrite were the only metallic minerals observed by the writer. These veins have never been carefully tested, and if, as it seems, they are confined to the syenite, there appears to be no reason why a little careful prospecting in that rock would not be worth while. These veins occur most frequently where the syenite has been sheared, sometimes with the formation of a chlorite schist not unlike that in the Keewatin. Calcite is the usual gangue mineral, though quartz is sometimes present, especially on the sides of the veins.

SIMCOE DISTRICT, ONTARIO.

(W. A. Johnston.)

The field work of the past season was a continuation of the topographical and geological mapping of a portion of the Lake Simcoe district, Ontario. In carrying on the topographical work the plane-table method was used, and field maps were drawn on a fractional scale of 1:48,000, which, on the published map, will be reduced to 1:62,500, or nearly 1 mile to 1 inch. Topographical features are shown by contours at intervals of 20 feet, instead of 25 feet, which latter was the contour interval used previously in the field work in this district.

Field work lasted from June 2 until November 4, in which work the following assisted: Geo. H. Burbridge, L. B. Adams, R. L. Junkin, James I. MacKay, W. T. May, and C. B. P. Fitzgerald.

LOCATION AND AREA.

During the past season the sketching on the Orillia sheet, with contours at intervals of 20 feet, was completed. This sheet is bounded by latitudes 44° 30′ and 44° 45′, and longitudes 79° 30′ and 79° 45′, and includes an area of about 140 square miles, exclusive of the portions occupied by Lakes Simcoe and Couchiching. The topographical work on the Balsam Lake sheet was also completed, with the exception of the sketching, which was only partly done. The Balsam Lake sheet is bounded by latitudes 44° 30′ and 44° 45′ and longitudes 78° 45′ and 79° 00′, and has an area of about 170 square miles exclusive of the portions occupied by a number of small lakes

PREVIOUS WORK.

As stated in last year's Summary Report, the previous work of the Geological Survey in this district was done by Mr. Alexander Murray, in 1852 and 1853, the results of which are given in the Geology of Canada, 1863.

General Character of the District.

The maximum relief within the limits of the Orillia sheet is about 400 feet, the highest portion being in the vicinity of Rugby P. O., where morainic hills rise to 1,050 feet above sea-level, while the lowest portion is the valley of North river, in the northwest corner of the sheet. In the southern portions of both the Orillia and Balsam Lake sheets the solid rocks are deeply buried beneath a heavy mantle of drift, but in the northern parts the flat lying Ordovician limestones are well exposed, and near their contact with the Pre-Cambrian rocks generally form an escarpment which varies from a few feet to upwards of 100 feet in height. The limestones have a gentle dip towards the southwest, generally not exceeding 30 feet to the mile, and are rarely faulted or folded.

General Geology.

TABLE OF FORMATIONS.

Recent	Humus, sand dunes, marls, etc.
Pleistocene	Raised beaches, fluviatile and lacustrine sands, gravels and clays.
	Glacial clays, boulder clays and sands; fluvio-glacial sands and gravels.
	Sands, silts, gravels, and clay, generally stratified.
	Till, or boulder clay.
Ordovician—Lower Trenton	Kirkfield limestone (group) (new); the upper portion only included in the Trenton. The lower portion includes the Crinoid and Dalmanella sancti-pauli beds which are below the base of the typical Trenton in New York state.
	Hiatus.
	Coboconk limestone, correlated with the Leray limestone (Cherty Streptelasma beds) which the New York State geologists have included in the Lowville as the upper member.
	Lowville (Birdseye) limestone; dove-coloured limestone, with basal series of sandstone, shales, etc.
Pre-Cambrian	

DESCRIPTION OF FORMATIONS.

Ordovician.

Lower Trenton to Lowville (Birdseye).

In the southern portion of the area of Balsam Lake sheet the limestones of the lower Trenton are well exposed, and underlie the greater portion of the area south and west of Balsam lake. In a cutting made on the Trent Valley canal, between Balsam lake and Kirkfield, a section is exposed from which great numbers of crinoids, cystids, and star-fishes have been collected. In this section the cherty Streptelasma beds (Leray limestone which the New York State geologists have included in the Lowville under the name of the Leray limestone member[1]) are 'followed by a few feet of thin-bedded, shaly limestone, carrying *Dalmanella sancti-pauli, Orthis tricenaria,* and other fossils, indicating the upper part of the Decorah shale of Iowa and Minnesota, and suggesting overlap eastward from that area. A very thin corresponding bed, with similar fossils, has been locally found in New York just below the Trenton.

'The Dalmanella sancti-pauli bed is succeeded by thicker bedded sub-crystalline limestone, with black shaly partings containing great numbers of crinoids and cystids, of species found elsewhere in America only in the beds regarded as older than the base of the typical Trenton in central New York. At Ottawa, Canada, they are found at the base of the Trenton; in Minnesota they occur in the lower part of the "Fusispira bed," in or about the middle of what I propose to call the Prosser limestone; in central Kentucky they are found in the Curdsville limestone, which lies between the local equivalent of the cherty "lower Black River" (Leray limestone) and the Hermitage formation, which in Kentucky and Tennessee is the lowest division of the Trenton group.

'The stratigraphic interval between the Lowville and the Prasopera bed of the Trenton, as developed in New York and Ontario, indicates a very shallow, oscillating sea. The unequal distribution of the beds and their structural relations suggest, especially in view of the fact that the corresponding interval is represented in north-eastern Tennessee by as much as 500 feet of limestone, frequent and long continued sea-withdrawal.'[2]

In view of the fact, as above stated by Mr. Ulrich, that both the crinoid and the Dalmanella sancti-pauli beds of south-central Ontario are older than the base of the typical Trenton in New York state, and since for purposes of mapping in the Simcoe district the crinoid and Dalmanella sancti-pauli beds cannot be separated from the limestones of the lower Trenton, this series of limestones has been provisionally

[1]New York State Museum, Bulletin 138, p. 72.
[2]Communication from Mr. O. E. Ulrich to the Director of this Survey.

named the Kirkfield limestone group, from the village of Kirkfield, in the county of Victoria, near which they are best exposed. Since the Black River group as now fixed by the New York State geologists does not, apparently, include limestones of equivalent age to the Crinoid and Dalmanella sancti-pauli beds, it would also seem that an age term should be given to include the limestones as developed in western sections, between the base of the typical Trenton and the top of the Black River.

Underlying the Trenton limestones in New York State there is a series of limestones which the New York State geologists (returning to the old New York usage of Vanuxem, who named the Black River limestone from the limestone cliffs along that stream, for the beds beneath the Trenton) refer to the Black River group. This group comprises the Amsterdam limestone (new), the Watertown limestone (new) (formerly the Black River limestone), and the Lowville limestone with Leray limestone member (new).[1]

In New York state the limestones of the Black River group pass downward into the Pamelia limestone of Upper Stones River age, which in turn is underlain by the Theresa formation, the upper member of which is of early Beekmantown (Calciferous) age.[2]

Regarding the extension of these formations into Ontario Mr. E. O. Ulrich states:—[3]

'In New York north of Watertown, and in the vicinity of Kingston, Ontario, the Pamelia limestone, which is the northern equivalent of the Upper Stones River of the Appalachian valley, locally rests directly on Pre-Cambrian crystalline rocks. In New York, Ozarkian sandstone, and limestone, respectively the Potsdam and the lower part of the Theresa formation, and early Beekmantown limestone forming the top member of the Theresa, commonly intervene between the Pre-Cambrian and the base of the Pamelia. At Kingston, and to the north and northwest of that point, the Pamelia usually is in contact with the Pre-Cambrian, with only here and there small. intervening remnants of Potsdam sandstone in old down-warped embayments.

'The Pamelia wedges out at some undetermined point between Kingston and Lake Simcoe, being absent at the latter locality, and thence northward to Michigan.

'The supposed Chazy sandstone of south-central Ontario proves to be basal Lowville, the initial deposits of which consist of red and green shales and sandstones, with local intercalations of thin limestones containing Lowville fossils.'

In the Simcoe district of Ontario the following generalized section, in descending order, of limestones, sandstone, and shales, which immediately underlie the Kirkfield limestones and rest unconformably upon the Pre-Cambrian crystalline rocks, occurs:—

(1.) Dark blue to grey nodular and cherty limestones generally in massive beds from 1 to 3 feet thick. Fossils: *Girvanella* sp., *Columnaria Halli, Tetradium fibratum, Streptelasma profundum, Beatricea gracilis, Escharopera subrecta?, Nicholsonella* cf. *laminata* and *cumulata, Strophomena filitexta var., Refinesquina minnesotensis?, Orthis tricenaria. Camerella panderi*, var. nov. *Ctenodonta* cf. *Logani, C.* cf. *Scofieldi, Helicotoma planulata, Lophospire* sp. undet., *Hormotoma Salteri canadensis, Orthoceras*—small, pencil size, *O.* large species, externally resembling *Ormoceras tenuifilum, Actinoceras* sp. undet., *Cycloceras*, sp. undet., *C.*———*? arenoliratum.* Coboconk limestone correlated with the Leray limestone which the New York State geologists have included in the Lowville as the upper member. . . . . .10—20 feet.

(2.) Dove-coloured, fine-grained, even bedded limestone, in beds averaging 1 foot in thickness. In the upper portion the characteristic vertical calcite tubes are abundant, and the beds have a peculiar interlocking tooth-like arrangement at their contact. Towards the base the beds weather white and are separated

[1] New York State Museum, Bulletin 138, p. 72.
[2] New York State Museum, Bulletin 140, pp. 127-128.
[3] Communication cited above.

by thin layers of greenish sandy shale. Fossils: *Tetradium cellulosum,* Hall, *?Phytopsis tubulosum,* Hall, *Strophomena cf. filitexta, Gyronema* sp. undet., *Leperditia fabulites, var., Isochilina armata,* Walcott, *Bathyurus extans,* Hall, *Bathyurus spiniger,* Hall, *Ctenodonta cf. gibberula, Liospira* sp. undet., *Hermotoma angustata, Trochonema* sp. undet., *Orthoceras* near *O. recticameratum, Cycloceras* sp. nov. (near *O. perroti,* Clarke), *Isochilina armata*. . . . . .20 feet.

(3.) Greenish grey impure magnesian limestone, generally in compact beds which weather brownish to pink, and are characterized by numbers of drusy cavities. No fossils. . . . . .6—8 feet.

(4.) Fossiliferous, blue to dove-coloured limestone containing: *Rafinesquina minnesotensis, Cyrtodonta* n. sp.? closely allied to *C. Janesvillensis* and *C. huronensis C.—Sillimanensis? Vanuxemia rotundata, Pterotheca attenuata, P.*—sp. undet., *Helicotoma* n. sp., *Liospira progne, L.—vitruvia, Eotomaria vicinus, Clathrospira subconica, Lophospira concinnula var., Holopea cf. concinnula, Subulites* n. sp. (near *S. regularis*), *Cameroceras* sp. undet., *Orthoceras cf. recticamerata, Isotelus, cf. obtusus, Strophomena filitexta var.* (Lowville var.), *Leperditia fabulites,* Conrad, *Isochilina armata,* Walcott. . . . . .6—10 feet.

(5.) Impure magnesian limestone in compact beds, on fresh fracture greenish grey in colour and weathering to yellowish brown. . . . . .8—10 feet.

(6.) Red and green shales and sandstones with local intercalations of thin dove-coloured limestones, and at the base locally a few feet of coarse grit or arkose resting unconformably upon the Pre-Cambrian crystalline rocks. .10—20 feet.

The fossils mentioned as occurring in the above described section were all identified by Mr. E. O. Ulrich, of the U. S. Geological Survey. Mr. Ulrich states that No. 1 of the above section is equivalent to the cherty lower bed of Cushing and Ruedemann's Black River limestone in New York State, and that the fossils of the balance of the section are all of Lowville species. Mr. Ulrich is of the opinion that the cherty beds should be included in the Lowville, for reasons which will be given in the sequel, and that they should be given a distinct name derived from some locality in the district. Accordingly these beds have been provisionally named the Coboconk limestone, from the village of Coboconk in the county of Victoria, Ontario. In a preliminary paper on the 'Lower Portion of the Palæozoic Section in Northwestern New York,'[1] Mr. H. P. Cushing unites the cherty beds with the '7 foot tier' to form the Black River limestone, but in a later report of the New York State Survey, as stated above, these beds are referred to the Lowville under the name of the Leray limestone member with the Lowville as a subdivision of the Black River group. If the cherty limestones are included in the Lowville under the name of the Leray limestone member, it would seem that the balance of the Lowville should receive a name derived from the district in which the typical Lowville is exposed.

The significance of the term Black River as a formational name has long been in question. According to the original definition of the Black River limestone, as given by Vanuxem in the Geology of New York, 1842, the Black River included all the beds between the Trenton and the Calciferous in the Mohawk and Black River valleys. This definition was later modified by Hall in 1847,[2] and the Black River was restricted to the "7 foot tier," and the underlying dove-coloured beds referred to the Birdseye, to which definition Clarke and Schuchert's Black River and Lowville apparently conformed.

In the section near Montreal, described in the Geology of Canada, 1863, pp. 136-137, the upper 10 feet are referred to the Black River, and the lower 28 feet to the Birdseye. It was recognized, however, that the line of demarcation between the two appears frequently to become very indistinct in Canada, and accordingly the two formations were grouped together. The upper 10 feet in this section apparently

[1]Bulletin of the Geological Society of America, Vol. 19, pp. 155, 176.
[2]Natural History of New York, Palæontology, Vol. I.

represented the '7 foot tier' of Hall, 1847, but as a distinct formation these beds have not been generally recognized in Canada.

In later writings some Canadian geologists have dropped the term Birdseye and made the Black River include the limestones which were supposed to belong to the Birdseye, but the lower limit of the formation does not appear to have been definitely fixed.

In the Simcoe district of Ontario the original Black River limestone of Hall (7 foot tier) is presumably absent, as its typical fossils have not been found. The fine-grained, dove-coloured limestones are relatively much thicker than the overlying cherty beds, and are characterized by fossils of Lowville age. The cherty beds, although only about 20 feet in thickness, are remarkably persistent and uniform in character, and constitute an easily recognizable horizon.

The uniting of the cherty beds with the Black River is objectionable on the grounds that, according to the original definition of the Black River limestone, it meant either all the beds between the Trenton and the Calciferous in the Mohawk and Black River valleys, or only the '7 foot tier,' and the inclusion of the cherty beds in the Black River would put a new interpretation on the term.

On the other hand, these beds are apparently more closely related faunally and lithologically to the original Black River of Hall than to the Lowville limestone, and on account of their persistent and uniform character it would appear that they should be separated from the Lowville. That the cherty beds, however, should be united with the Lowville is considered by Mr. Ulrich to be in the best interests of stratigraphical classifications, for the following reason.[1]

'Considering the composition and mapping qualities of the lower Mohawkian formations in Ontario, New York, Pennsylvania, Virginia, Tennessee, and Kentucky, the only place where the exigencies of areal mapping are as well or perhaps better served by associating the cherty bed with the typical (7 foot tier) Black River than with the Lowville, is in the vicinity of Watertown, N.Y. Elsewhere, for one reason or another, the separation of the cherty bed from the Black River is manifestly desirable. As a rule, the zone of the 7 foot tier cannot be recognized, and presumably is absent. In fact this zone, at least so far as its outcrop is concerned, is very limited even in New York. In this State it is confined to the north of the divide between the Black and Mohawk rivers. The cherty zone, on the contrary, is locally developed on both sides of this divide, and maintains its lithic and faunal characters as far from New York as Georgian bay to the northwest, and Tennessee to the southwest. In east middle Tennessee, and central Kentucky, the cherty zone is rarely present, and when it is, the zone is naturally associated with the underlying typical Lowville. On the flanks of these domes of the Cincinnati uplift the bed cannot very well be separately mapped, being only a few feet thick at its best, and further, being followed by another thin formation, the Hermitage, which is the first of the divisions of the Trenton group.

'Although the cherty bed represents a stage of geological history that is readily distinguished from the typical Lowville by differences in distribution of sediments and by faunal peculiarities, it is nevertheless a fact that the break between the Cherty bed and the later typical Black River limestone (7 foot tier) is much more important in every respect. That actual and widespread sea-withdrawal occurred at this time is unmistakably indicated by the irregularities of contact between the two beds at Watertown, N.Y., and by the rather general absence of the upper zone. The fauna of the latter is decidedly different from that of the underlying cherty zone; while the time importance of the break is suggested by the much greater thickness of limestone deposits in northeastern Tennessee, regarded as representing the corresponding parts of the stratigraphic column.'

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* Communications cited above.

THE DEVONIAN OF SOUTHWESTERN ONTARIO.

(C. R. Stauffer.)

The work of the field season (1910) just past consisted in a stratigraphical and palæontological study of the Devonian of the southwestern part of Ontario. The object has been to re-determine the formational units into which this important system may be divided, and to collect any other data regarding it that might be available; the whole for use in the prospective geological mapping of the area. Only three months were spent in the field, and, therefore, the work must be classed as preliminary. However, a considerable amount of material has been collected and is being worked up for the final report, which it is planned to make as complete as possible.

Distribution of the Devonian.—The portion of the Province covered by Devonian formations may be roughly described as that part lying to the south and west of a line drawn from Fort Erie westward through Humberstone, Dunnville, and Hagersville, almost to Woodstock; then northward through St. Marys, Wingham, and Formosa, reaching the northernmost point near Cargill; then swinging around to the westward, returning to the south through the eastern part of Port Albert and Goderich, striking the Lake Huron shore at a point somewhat south of the town last named.

At some places the Devonian formations extend slightly beyond this line, while at others they do not quite reach it. There may also be outliers to the east and north of it, but in a region for the most part heavily drift covered they are difficult to locate, and indefinite when found. Within the area there are also localities where the Devonian is entirely wanting; for instance, at Teeswater and Anderdon. But in general the region, as outlined above, is covered by a great and continuous mass of rocks belonging to the system under discussion.

The Silurian-Devonian Contact.—The Devonian system rests unconformably on the Silurian. This contact is between beds of varying ages in both systems. The top layers of the Silurian, from Fort Erie to Goderich, show marked signs of erosion, and often evidences of weathering to a considerable depth which they had suffered prior to the deposition of the overlying strata. Arenaceous material from the sediments which form the Oriskany sandstone sifted through cracks and joints in the Silurian, and may now be found as thin vein-like seams of sand cutting through the limestone in all directions, in some cases to depths of 5 feet and more below the contact. Even where no Oriskany formation occurs this sand may be found.

The Corniferous (Onondaga) limestone usually overlaps the Oriskany sandstone, and covers a much greater area. It is, therefore, the contact between this formation and the Silurian which one observes in most places where the two systems are exposed together. When this is the case the layers of the Corniferous (Onondaga) limestone are sometimes found to be made up of rounded pebbles of the drab to buff-coloured Silurian limestones, embedded in a matrix of grey Corniferous (Onondaga) limestone. An excellent place to observe this is along the Maitland river near Goderich, where the pebbles of Silurian limestone are mingled with Devonian corals and brachiopods.

Formational Divisions of the Devonian.—The divisions of the Devonian, recognized in former studies of this region,[1] are as follows:—

[1] See Logan, Sir William E., Geology of Canada, 1863, p. 20; also pp. 359-380, and p. 932. Also Dawson, Sir J. William, Handbook of Canadian Geology, 1889, p. 175. Also Brumell, H.P.H., Geological Survey of Canada, Annua Report, Vol. V, pt. Q, 1891, p. 5.

Devonian	Upper	Chemung beds.
		Portage beds.
		(Genesee shale.)
	Middle	Hamilton beds.
		Corniferous (Onondaga) limestone.
		Oriskany sandstone.
	Lower	(Wanting.)

These subdivisions were adopted by Logan from the New York classification, but in so doing he took over the names rather than the formational units. Logan considered the Esopus (Cauda-galli) grit, and the Schoharie grit of New York, as local phases of the Oriskany sandstone which could not be distinguished from the latter in Ontario. The boundaries of the Corniferous (Onondaga) limestone he extended so as to include not only the Corniferous limestone, as then recognized in New York, but the underlying Onondaga limestone as well. In support of this union he says: 'in western Canada, we find that many of the fossils of the Corniferous limestone pass up from the Oriskany sandstone; and the intermediate Onondaga limestone, with its encrinites, can no longer be recognized as a distinct formation. We, therefore, unite the two limestones under the name of the Corniferous limestone.'[1] It is worthy of note that the same union of formations was made at a much later date in New York state. Under the name Hamilton formation Logan included all of the strata found in Ontario between the Corniferous (Onondaga) limestone and the black shales of the upper Devonian. The remaining Devonian beds were united into the Portage and Chemung group, which was treated as one division, and included the shales usually referred to the Genesee in the eastern states.

These subdivisions, with the modifications imposed upon them by Logan, fit the Devonian of Ontario very well indeed. The Oriskany sandstone, and the Corniferous (Onondaga) limestone, as found in Ontario, especially near the eastern end of Lake Erie, are almost the exact equivalents of the same formations as they are now recognized in New York state. Logan, however, seems to have included the basal layers of the Hamilton with the Corniferous (Onondaga) limestone at St. Marys and Goderich. Then too, there is a thin statum of shale near Selkirk, which indicates conditions similar to those which produced the Marcellus, and apparently at the same horizon as that formation in New York. The well records in the oil producing region of southwestern Ontario have made it possible to separate, with a fair degree of accuracy, the Portage and Chemung beds, and hence they may be given separately.

It has thus appeared expedient to continue the use of Logan's classification, with a few minor changes in the form of the names, in the present work.

The Oriskany is a coarse massive sandstone, which at places approaches a true conglomerate of small quartz pebbles. It carries a pure Oriskany fauna. Only the uppermost beds, which are of a cherty character, contain species usually found in the typical Corniferous (Onondaga), and even in these none of the most characteristic Oriskany fossils were found. Indeed, it seems quite certain that the beds, which carry true Corniferous (Onondaga) fossils, should be referred to that formation. The greatest thickness of the Oriskany sandstone observed was a trifle less than 20 feet, although it is probably somewhat thicker at other places, while at still others scarcely a foot of it is to be found.

The Corniferous (Onondaga) limestone lies unconformably on the Oriskany sandstone, where the latter occurs, and overlaps it at other places so that it rests upon the Silurian limestones. Indeed, it appears that the advancing Corniferous (Onondaga) sea destroyed a considerable part of the Oriskany sandstone, incorporating the siliceous material into its basal layers. The Corniferous (Onondaga) varies from the dark coloured, cherty limestone of the Fort Erie region, to the light grey, pure limestones of the Pelee Island and Amherstburg regions. The former is the same type as

[2] Geology of Canada, 1863, p. 362.

that which occurs in New York state; the latter, as that of Michigan and Ohio. The formation is abundantly fossiliferous, and this is especially true in the southwestern part of the Province. The thickness varies considerably in different parts of the area covered, but, in general, increases to the westward, while to the north its eastern thickness is maintained. At Goderich, where both contacts are shown, the thickness is about 32 feet. Since the basal portion of the Hamilton formation is a limestone, and in the greater part of the region there seems to be a gradual transition from the Corniferous (Onondaga) to the Hamilton, it is difficult to draw a dividing line between the two, while in well records this is next to impossible. It thus happens that the great thicknesses, sometimes assigned to the Corniferous (Onondaga) limestone, are likely to be in error. Fossils are abundant, and of characteristic Corniferous (Onondaga) types.

The Hamilton beds consist of soft blue shales and of limestones which approach in lithological appearance the character of the western Corniferous (Onondaga). There have been distinguished three of these limestones—a lower, middle, and upper—which are separated by considerable thicknesses of soft shale. But the number of limestone layers and calcareous bands is far greater. At no place in the Province is there more than a mere fraction of the formation exposed, but well records make its thickness approximately 350 feet, although 400 feet of strata, referred to the Hamilton, have been penetrated at Sarnia. The upper limestone, and a portion of the upper shales, outcrop in the region about Thedford, while the lower limestone outcrops at St. Marys and at Goderich; which indicates that the Hamilton beds cover a much more extensive area than has thus far appeared on any geological map of the Province. The fauna is abundant, indeed the Thedford region has long been the favourite collecting ground for Hamilton forms.

Overlying the Hamilton beds are the black shales of the upper Devonian. These are best shown at Kettle point, on Lake Huron, although they are also to be found outcropping along the Sydenham river and some of its branches. The outcropping shales are black, bituminous, and rather fissile. They contain large spherical concretions similar to those found in the black shales of this age in Ohio and New York. A few animal fossils may be found, and the sporangia of certain plants occur in great abundance, while long strap-like leaves are occasionally found. At Corunna, in Moore township, where more than 200 feet of these shales have been penetrated by the drill, they include a 20 foot bed of arenaceous material reported to be a greenish sandstone. At Cleveland, Ohio, these sandy beds outcrop along the Cuyahoga river, also along the shore of Lake Erie, and are composed of very thin layers of sandstone, alternating with soft bluish green shales (the Chagrin formation) which carry the Chemung fauna of New York. Probably this black shale deposit of Ontario represents the whole upper Devonian of the eastern part of the United States.

Economic Products.—Every Devonian formation of the Province is of economic importance. The Oriskany sandstone has been used quite extensively as a heavy building stone, to which purpose some layers are admirably suited. The Corniferous (Onondaga) limestone is burned for lime, and used in the manufacture of Portland cement. It also furnishes an excellent building stone; but by far its most important use is in supplying crushed rock for concrete and railway ballast. The greatest economic importance of the Corniferous (Onondaga), however, is as a reservoir for the crude oil of the Petrolia and Oil Springs districts. The Hamilton shales have been used in the manufacture of brick and tile, while some of the interbedded calcareous layers have found local use as a building stone. The black shales of the upper Devonian (Portage and Chemung) have not yet been used, but there is already in existence a company which hopes to recover their hydrocarbons by the process of distillation; so it is not improbable that even the black shales may contribute to the ultimate list of economic products from the Devonian.

MONTREAL RIVER DISTRICT.

(W. H. Collins.)

During the field season of 1910 the writer completed an examination of the area in Gowganda mining division upon which he has been engaged since 1908. He also began the detailed reconnaissance of a rectangle immediately south of this, 72 miles long from east to west by 48 miles from north to south. A map and report upon the former area, which has been explored jointly by the Geological Survey and the Ontario Bureau of Mines, are being prepared. When completed the work upon the latter area will furnish material for a regular map sheet similar to the already published Timiskaming (No. 138) and Sudbury (No. 125) sheets that adjoin it on the east and south, respectively. It will include all the country between W. long. 80° 20′ and W. long. 82° from N. lat. 46° 55′ to N. lat. 47° 40′. The work already done lies in the north-eastern part of this rectangle.

These two areas, which are contiguous, and in reality constitute but one, are geologically similar to the district in the neighbourhood of Lake Timiskaming. They also contain silver-cobalt ore deposits of the same type as those found near Cobalt, and in consequence, they have received much attention from prospectors during the past four years. The resultant demand for maps may be inferred from the fact that blue print copies from privately prepared compilations have found a ready sale. Geological information has been even more in demand, but could not be obtained. It was fortunate, therefore, that a larger field party than usual was provided for this year's work, as a correspondingly larger amount of much needed information was gained. However, even this acceleration is still insufficient to satisfy present requirements, much less future demands.

Efficient and ready assistance was given throughout the season by Messrs. H. C. Cooke, J. R. Marshall, E. R. Lloyd, T. L. Tanton, C. P. Sills, A.D. Macdonald, and E. J. Whittaker.

General Character of District.

TOPOGRAPHY.

The explored area lies within the Pre-Cambrian peneplain region of northern Ontario. Standing at an elevation of from 1,000 to 1,400 feet above the sea it constitutes part of an unevenly dissected plateau, which presents the characteristically gentle outlines produced by glaciation. It is essentially a hummocky rock surface, the inequalities of which appear as ridges and rounded hills from 50 to 600 feet high. A mantle of sand and gravel, deposited by glacial ice, rests upon this rock surface. Ordinarily the soil sheet is thin, and confined to the lower levels of the country, the rocky hill tops being washed bare. Its general effect, therefore, is to smooth the topographical aspect of the old rock floor; but, in a few localities, it is thick enough to bury even the hills, and there gives rise to a surface of much softer relief, more like the agricultural portions of Ontario. The townships of Lawson and Corkill, and their vicinity, are of this character. A similar area occurs in Fawcett, Ogilvie, Dufferin, and adjacent townships.

Practically the whole country is densely forested. As in other parts of the Pre-Cambrian region, lakes are very numerous, especially where the country is rocky. Heavily drift covered portions, like those above mentioned, are not so well supplied. None of the lakes, however, are large; few exceed 5 miles in length. They are drained

by a large number of creeks and brooks, which form the headwaters of Montreal, Sturgeon, and Wanapitei rivers. Few of these tributary streams are large enough to be easily navigated, and only towards the edge of the area covered by the summer's work do the rivers they feed attain a considerable size. Hence canoe travel, the ordinary means of traversing the country, is exceptionally difficult.

FLORA AND FAUNA.

The forests, the natural covering of the region—as regards the kinds of trees composing them and their rate of growth—vary with the drainage, and with the depth and richness of the soil that nourishes them. So definite are these relationships that, with a little experience, the nature of the ground can be safely deduced from observation of the forest growing upon it. Practically all the low, wet lands support swamps of black spruce, with a few cedars and tamaracks. Dry, well drained soil is covered by mixed forests of white and red pine, and jackpine (*Pinus banksiana),* balsam, poplar, white and yellow birch, and even maple. The more arid, sandy tracts are occupied almost exclusively by spindly growths of banksian pine.

Individual trees of nearly all these species grow rapidly where the soil is sufficiently deep and well drained. At many points in the district white pine, the most valuable, attains a diameter of 40 inches. However, it is seldom abundant, though there seems to be no reason why it should not be if it were planted and protected. West of Shiningtree lake it forms splendid groves, individual trees in which range from 15 to 40 inches in diameter. Cedar appears to be near its northern limit and reaches only a somewhat stunted growth. A few trees 2 feet in diameter were observed in Leonard township. Like the tamarack, cedar occurs only sparingly, and in a few localities. An immense supply of pulpwood can be furnished by the spruce forests which cover a greater part of the district. Banksian pines, under favourable conditions, grow to a size suitable for making railway sleepers.

Of the deciduous trees, the birches and poplars attain a splendid development. The sugar maple (*Acer saccharum*) seldom grows more than 6 inches in diameter and 30 feet high, but numerous individuals a foot through were seen near Gowganda junction, the present terminus of the Canadian Northern Ontario railway. A few elms occur along Wanapitei river, in the same part of the district.

A few attempts to raise vegetables—potatoes, onions, and other hardy garden stuff—have been made at Shiningtree lake, and Smoothwater lake, with very fair success. Timothy, accidentally sown along the winter road from Gowganda junction to Gowganda, was found growing well.

TRANSPORTATION.

The district may be entered either from the Timiskaming and Northern Ontario railway, or the Canadian Northern Ontario railway. The former, extending from North Bay northward to Cochrane, on the Grand Trunk Pacific railway, passes 30 miles east of the district. From Latchford station, where it crosses Montreal river, small steamers and gasoline launches ply 56 miles upstream to Elk lake, and from that point a wagon road 27 miles long reaches to Gowganda. From Timagami station the eastern side of the field is readily reached by way of Lake Timagami.

The Canadian Northern railway is built 65 miles northwest of Sudbury and is being continued in the same direction. From Gowganada Junction, the present terminus, a winter road 45 miles long communicates with Gowganda, and during the summer good canoe routes are available.

GENERAL GEOLOGY.

The general structural features of the district are simple. A complex of ancient crystalline rocks, consisting of greenschists and granites or granite gneisses, underlies

everything else. The greenschists—themselves a complex assemblage of various highly metamorphosed intrusives—occur as elongated areas surrounded by the granites and gneisses, which are younger and intrusive. The surface of this crystalline basement constitutes a greatly eroded peneplain. Upon it rests a mantle of well preserved, nearly flat-lying sedimentary formations, composed chiefly of the fragmental materials that resulted from its denudation. Both basement and mantle are intruded by younger quartz and olivine diabases. All these are of Pre-Cambrian age. Subsequent erosion has developed upon them the present characteristic peneplanated surface, upon which lies a thin, discontinuous film of glacial materials.

TABLE OF FORMATIONS.

Pleistocene	Loose glacial till.
Unconformity.	
	Dykes of olivine diabase.
Post Huronian intrusives	Sills and dykes of quartz diabase.
Huronian	Quartzite, quartz conglomerate, arkose and arenaceous limestone. Slight unconformity. Rhyolitic lava and agglomerate. Conglomerate, greywacke, slate, arkose, and quartzite.
Unconformity.	
Laurentian	Batholithic intrusions of hornblende and biotite granites, and granodiorite and their gneissic equivalents.
Keewatin	Sheared acid and basic eruptives, iron formation and metamorphic hornblende and biotite gneisses.

KEEWATIN.

Most of the complex known as the Keewatin is of igneous origin, and consists of a great variety of extrusive and intrusive rocks, which, through subsequent metamorphism, have been altered to chloritic and sericitic schists. In their present condition originally unlike types are so much alike that microscopic examination is often required to distinguish them. But structures that indicate repeated volcanic activity are, in places, still preserved. Sheared and badly decomposed diabases in Fawcett and MacMurchy townships exhibit amygdaloidal and ellipsoidal structures, while other neighbouring types are probably altered volcanic tuffs. Similar appearances are presented by a light grey, porphyritic type that covers part of Tyrrell township. Its agglomeratic phases are unmistakable. On the other hand, a number of small bodies of harzburgite are plainly intrusive in nature, and the complex is also cut by a variety of dyke rocks, whose age, however, is possibly post Keewatin.

Small bands of iron formation exist in Leonard and Tyrrell townships.

Near its contact with the younger Laurentian granitic rocks, the Keewatin has been frayed, and rendered highly crystalline. A glistening black hornblende gneiss or schist is the most common product of this contact metamorphism.

LAURENTIAN.

Little Laurentian was encountered this season. That observed in Dufferin township and vicinity is a biotite granite gneiss, containing numerous ribbon-shaped inclusions of Keewatin hornblende gneiss.

HURONIAN.

All the sedimentary mantle that overlies the Keewatin-Laurentian basement is classified as Huronian. It is, however, capable of subdivision into a series of prevalently dark-coloured rocks, comprising conglomerate, greywacke, arkose, and banded slate, and one of essentially quartzitic nature that includes quartzitic, quartz conglomerate, and arkose. In the Cobalt district W. G. Miller found the quartzitic series resting unconformably upon the other, from which it would appear that a dis-

tinction in age as well as lithological character exists between them. In Montreal River district a similar unconformity has been found near Obushkong lake, by A. G. Burrows. In Gamble township, also on the east boundary of Ray township, slate gives place to quartzite with marked abruptness, though the actual contact planes were not located. At other points, however, there appears to be a conformable transition from slate to quartzite, thus implying that the gap between the two series is a slight one and perhaps only local.

The dark series consists basally of conglomerate, but the relative positions of the greywacke, slate, and arkose members are inconstant. In different localities the conglomerate is cemented by one or other of these materials, and succeeded above by the same. Conglomerate beds also occur higher up in the series.

The quartzitic series is composed essentially of impure quartzite, which graduates locally into a pure white quartzite, or into arkose. It also becomes conglomeratic, the pebbles being predominantly of quartz. On Smoothwater lake, and some miles south of Florence lake, there are beds rich enough in calcium carbonate to be termed limestone. The limestone is not crystalline, and, on Smoothwater lake, retains perfect ripple marks. Within a disturbed zone, extending from MacPherson lake to Smoothwater lake, the quartzite, whose clastic texture is ordinarily quite perceptible, is associated with a cryptocrystalline, chert-like variety, also ripple-marked.

Although sedimentation was the predominant Huronian process in this district, there were also local volcanic outbursts. The banded slate and arkose in Leonard township contain interbedded deposits of a coarse rhyolitic agglomerate. A small lava flow of the same pale grey, fine-grained rock occurs between Black and Spider lakes, at the north side of this township. Amygdules filled with calcite or quartz are abundant near the top of the sheet.

Over most of the area the Huronian beds lie in gentle folds, with dips seldom exceeding 30°. The chief exceptions to this rule are in proximity to the rhyolitic extrusive area, and along the disturbed zone between MacPherson and Smoothwater lakes. This zone varies in width from 1 to 4 miles, and curves gradually from northwest to nearly due west. Within it the quartzites have been faulted, folded, and locally rendered as schistose as typical Keewatin rocks. The beds on either side are only slightly disturbed.

QUARTZ DIABASE.

Diabase intrusions of the same nature as those at Cobalt, Elk Lake, and Gowganda districts occur in this area. They are either dykes, which traverse Keewatin, Laurentian, and Huronian alike, or comparatively horizontal sills, wherever the Huronian strata have offered mechanical conditions favourable for the formation of such bodies. In most cases the latter have been deeply dissected by erosive forces and possess highly irregular outlines.

The diabase composing the sills is usually coarse-grained, and has, in places, a brecciated appearance where, by partial differentiation, patches of an unusually coarse, feldspathic type are enclosed in the ordinary diabase. Small dykes of light grey or pink aplite, an acid differentiate from the original magma, traverse the sill diabase sparingly.

OLIVINE DIABASE.

All the preceding rocks are cut by occasional dykes of olivine diabase. Though somewhat similar to the quartz diabase this variety can usually be recognized by the presence of large, well formed phenocrysts of plagoiclase, the largest of which are 3 or 4 inches long.

PLEISTOCENE DEPOSITS.

The accumulations of loose sand, loam, and gravel lying upon the Pre-Cambrian rocks are glacial and unstratified. In only a few localities are they deep enough to effectively hide the old rock floor. Parts of the townships of Corkill, Lawson, and vicinity are covered with light sand to a depth of over 100 feet. A like area occupies portions of Ogilvie, Browning, Dufferin, and adjacent townships.

Glacial structures are fairly common. Morainic ridges occur south of Smoothwater lake, and in Corkill township. A symmetrical pothole 18 inches in diameter, and about the same depth, may be seen in the quartzite on the shore of Apex lake, Corley township. Boulders and glacial striæ are abundant, the latter pursuing courses varying from S 10° E to S 30° W magnetic.

Economic Geology.

GOLD.

The Keewatin area near Shiningtree and Pigeon lakes contains numerous irregular veins and stringers of quartz sparingly mineralized with pyrite. Some of these yield low gold values, in consequence of which they attract desultory attention. A considerable number of claims of this character have been taken up recently in MacMurchy township, but, so far, no promising results have been obtained.

For years placer gold has been known to exist in the sands along Vermilion river, in the district of Sudbury, though operations for its recovery have been only tentative. Some work is now in progress in Meteor lake, a few miles north of Gowganda junction. However, as the locality lay beyond the area geologically examined and was hurriedly observed at the close of the season, little can be stated regarding the probable success of the venture.

SILVER.

Prospecting for silver is being continued with some vigour. The quartz diabase sills, and their immediate vicinities, are generally regarded as the most promising ground, and practically none of this ground remains unstaked. Several new discoveries have been made during the season.

Lawson Township.—Silver is now obtained in Lawson township. The Calcite Lake Mining Co. has a shaft sunk 103 feet on a vein that cuts the diabase on Mining Location L. O. 357, and ore containing much niccolite, small amounts of smaltite and chalcopyrite, and considerable leaf silver is being mined. The property is situated near the edge of a diabase mass underlain by Huronian greywacke. Several veins have been stripped, but present work is confined to one about 4 inches wide that traverses the diabase in a direction slightly south of east. Another vein 200 feet to the north contains barite instead of calcite as its gangue mineral.

Good samples of ore were also obtained on Mining Location H. B. 42, on June 25 of this year, by Messrs. A. Perron and Chas. Richardson, of Haileybury. The property, H. B. 42 and 43, consists of a narrow ridge of diabase rising out of the deep sand which covers most of the township. A shattered calcite vein, ranging from 4 to 12 inches in width, had been traced in an easterly direction for 60 feet and a test pit sunk 15 feet, when silver was discovered. The ore consists largely of smaltite, through which flakes of silver are richly distributed.

Silver is also reported to have been found on a neighbouring claim belonging to Mr. A. Peria.

Donovan Township.—A discovery has also been made on T. C. 385, just east of Lady Dufferin lake in Donovan township. Much of the locality is swampy, but the small exposed areas of diabase appear to belong to a sill resting upon Huronian

sedimentary beds. Four calcite veins, ranging from one-half to 4 inches in width have been exposed. Near the surface of one of these, which extends in an easterly direction, the calcite is mineralized by smaltite, niccolite, and native silver, for a distance of several yards. At the time of visit the title to this property was in litigation.

Two unsurveyed claims near Steele lake, on the north side of Donovan township, carry an irregular series of small veins, in which a little silver, cobalt bloom, smaltite, and niccolite have been found by Mr. D. Wollings.

Shiningtree District.—The Shiningtree district, in Leonard township, contains two discoveries. The first of these was made in May, 1909, on a group of claims owned by the Saville Exploration Co. Since then a large amount of assessment work has been performed, chiefly in surface exploration. As a result a second discovery of silver has been made, and in addition, other veins have been found to carry native bismuth, smaltite, and cobalt bloom. Both silver-bearing veins are narrow, averaging from 1 to 2 inches, and silver has been found at only one point in each.

Silver was also discovered during June, 1910, on H. S. 448, owned by Messrs. Sutcliffe, Neelands, and Herron. A group of seven parallel veins, striking at 20° magnetic, are distributed over a width of 300 feet. Three of these have been found to be mineralized with niccolite, smaltite, and chalcopyrite, and, in one, native silver has been found. Niccolite is especially abundant, this mineral occupying a width of 2 inches in one vein, for a distance of 20 feet. In the silver-bearing vein flakes of silver have been found for 15 feet along the vein, which is about 3 inches wide.

Veins well mineralized with smaltite, but as yet showing no silver, have been found upon the McLaughlin property west of Spider lake.

Leckie Township.—A few small grains of native silver have been discovered in a calcite vein on Mining Location W. D. 1126, in the township of Leckie. The vein extends 30 feet down the face of a diabase ridge in the northeast corner of the claim. Several other veins, carrying chalcopyrite and smaltite, have been uncovered. The property is owned by Messrs. Eplett and Caswell.

Rosie Creek District.—Mineralized calcite veins have also been found in Rosie creek district, in the townships of Browning and Unwin. A large portion of the area is covered deeply with sand, through which rise irregular, hilly masses of diabase. Huronian and Laurentian rocks also outcrop.

Silver is reported to have been found upon the Carufel claim, which lies just west of Saturday lake, in the northern part of Unwin. However, a visit was paid to this locality, and only a number of irregular quartz-calcite veins carrying smaltite, galena, stibnite, and chalcopyrite observed. They traverse quartz diabase of medium coarseness.

IRON.

A small area of Keewatin iron formation is exposed near the middle of Leonard township, near Wapus, or Fournier lake. To the north it disappears beneath the Huronian, while to the south the country is swampy and drift-covered. Patches of iron formation also occur in the southwestern corner of Tyrrell township, but whether continuous with the larger area around Fournier lake is problematical. The small patches in Tyrrell consist of a brilliantly coloured rock, consisting of alternating red and dark grey bands. In their neighbourhood the magnetic variation rises between 10° and 15°, but no other signs of an ore body were found.

The Fournier Lake area is composed largely of dull coloured, chloritic schists, that stand almost vertically and strike north and south. It contains a narrow ore body from 10 to 50 feet wide, that can be traced along the strike for a distance of

4,000 feet. Dip needle observations also suggest that another ore body underlies Fournier lake. The ore is a highly siliceous mixture of hematite and magnetite. Picked samples are said by Mr. Fournier to have yielded 52 per cent of metallic iron.

Practically the whole range is owned by MacKenzie and Mann, Ltd. Under the management of Mr. Fournier a well equipped camp is being established on Fournier lake. Diamond drills will be brought in from Burwash lake during the winter and exploratory drilling begun, it is expected, in January, 1911.

BARITE.

Some of the veins which cut the quartz diabase formation are filled with barite instead of calcite. Examples of such were seen in Lawson and Leonard townships. Commercially, however, they are too small for barite to be profitably extracted.

NORTHWESTERN QUEBEC ADJACENT TO THE INTERPROVINCIAL BOUNDARY AND THE NATIONAL TRANSCONTINENTAL RAILWAY.

(Morley E. Wilson.)

During the past season field work was carried on in that part of northwestern Quebec immediately adjacent to the Ontario boundary and the National Transcontinental railway. An attempt was made to gain some knowledge of the geology and mining possibilities of this region as far eastward as Kewagama lake; but detailed work was confined to an area of 800 square miles, in the vicinity of Lake Abitibi, comprising the following townships: La Reine, LaSarre, Roquemaure, Palmarolle, Hébécourt, Duparquet, Montleroy, and Duprat.

In mapping the areal geology of the district, the lakes and navigable streams were traversed in the customary manner, using the Rochon micrometer-telescope and surveyor's compass, while the smaller ponds were located and surveyed by means of chain and compass. The surveys made in this way, in conjunction with the interprovincial boundary line, and the numerous base, meridian, and township lines surveyed by the Crown Lands Department of Quebec, will furnish the necessary data for the preparation of a tolerably accurate and detailed map of the district.

I am indebted to Messrs. A. C. Simpson, N. B. Davis, J. S. Stewart, and L. E. Dagenais, who were attached to the party as student assistants, for the efficient manner in which they performed their work.

PREVIOUS WORK.

The earliest geological work in this region was an examination of the rocks exposed on the shores of Lake Abitibi, and along the Timiskaming-Abitibi canoe route, by Mr. Walter McOuat in the summer of 1872. The results of this investigation were published in the Report of Progress of the Geological Survey for 1872-73. Following this no further work was done in the area until the year 1901, when Mr. W. J. Wilson visited Lake Abitibi and made a geological survey of some of the leading waterways in its vicinity, which he described in the Summary Report of the Survey for that year.

In the summer of 1908 Mr. M. B. Baker, with a party of student assistants, made a geological examination of the Ontario portion of Lake Abitibi; his report, accompanied by a gelogical map of the district, being published in the report of the Ontario Bureau of Mines for 1909.

General Character of the District.

TOPOGRAPHY.

The country within the area mapped presents two strikingly different types of topography, a rocky hill country occurring in the southern townships and a flat clay-covered area in the north. Since the clays are of post-glacial, lacustrine deposition, they naturally occupy the depressions of the region, while the rocky, hill country forms the uplands.

The surface of the clay area presents a very uniform, flat, plain-like appearance, broken only, at wide intervals, by isolated outcrops of rock, or by hills or ridges of glacial drift. A few shallow, marshy ponds occur in this area, but throughout most of its extent lakes are entirely absent. The rivers in this district are wide,

and meandering where they traverse the easily transported, unconsolidated clay, but are interrupted by rapids and waterfalls where erosion has exposed the underlying rock.

The rocky hill district, although not characterized by striking differences in elevation, possesses a very uneven surface, hills from 300 to 400 feet above the surrounding country being not uncommon. This irregularity in the rocky surface, aided in some places by scattered glacial debris, has formed numerous basins now occupied by lakes. So numerous are these in the hill country, as contrasted with the clay flats, that the rocky district can be readily delimited on the map by the relative abundance of lakes. The streams of the hill country, owing to the relatively high elevation, are usually small, and abound in rapids and waterfalls as they descend northward to the clay belt.

There are two large bodies of water in the area, the eastern part of Lake Abitibi, and Agotawekami or Upper lake. The portion of Lake Abitibi included in the district under discussion occupies a very shallow depression in the clay belt. It has an area of about 50 square miles and a depth of less than 10 feet throughout the greater part of its extent. Lake Agotawekami is a picturesque body of water, with an irregular shore line and numerous rocky islands, characters common to most of the lakes of the hill country. It has an area of approximately 16 square miles.

With the exception of a very small area in the eastern part of Duprat township, which lies to the south of the St. Lawrence-Hudson Bay divide, the drainage of the region is entirely into Lake Abitibi, and thence by way of the Abitibi and Moose rivers to James bay.

COMMERCIAL POSSIBILITIES.

The lacustrine clays, which occur so extensively in this part of northern Quebec, afford a very good soil for the growth of agricultural products, yielding excellent crops of all the hardier cereals and vegetables. A number of townships have been outlined and subdivided by the provincial government in the vicinity of the National Transcontinental railway and will shortly be opened for settlement.

TRANSPORTATION AND COMMUNICATION.

Until recent years the long canoe route from Lake Timiskaming furnished the only means of access to this region; but with the construction of the Timiskaming and Northern Ontario railway, an alternative route by way of the Abitibi and Black rivers from McDougalls chute or Matheson was rendered available. A number of steamboats and launches were maintained by the Walsh Transportation Company on the route by way of Matheson, during the summers of 1908 and 1909, but with the progress of construction on the National Transcontinental railway this service became unnecessary, and has since been abandoned, the region being now most readily reached by train from Cochrane, Ont., the junction point of the Timiskaming and Northern Ontario and the National Transcontinental railways.

General Geology.

The rocks of this region belong almost entirely to the very oldest Pre-Cambrian, consisting largely of Keewatin, greenstone and green schist, but interrupted here and there by masses of granite diorite and related rocks, presumably of Laurentian age. Both the greenstone and green schist, and the granite and diorite are intruded locally by dikes of diabase, the latter, with the exception of unconsolidated Pleistocene or Recent materials, being the youngest rocks observed in the area.

The geological succession can hence be outlined in descending order as follows:—

Pleistocene and Recent—
  Post-Glacial: clay, sand, and gravel.
  Glacial: boulder clay, sand, and gravel.
    Unconformity.

Post-Huronian—
  Diabase.

Laurentian—
  Granite, syenite, and diorite.
    Igneous contact.

Keewatin—
  Slate and dolomite.
  Greenstone and green schist.

KEEWATIN.

The Keewatin rocks of the region may be subdivided into two classes, the first consisting of greenstone and green schist, and the second of slate and dolomite; the latter, however, is of very limited extent.

Greenstone and Green Schist.—Keewatin greenstone and green schist are the prevailing rock types throughout the entire extent of the area examined. These consist of a number of more or less metamorphosed, basic rocks, of a green or greenish grey colour, which are largely, if not entirely, of volcanic origin.

The greenstone consists largely of basalt and related rocks which have been highly chloritized and carbonated, but have not been dynamically metamorphosed. They are best developed in those portions of the district remote from Laurentian intrusives, and hence occur most abundantly in the country to the south of Lake Abitibi. In many places they show a remarkable development of amygdaloidal and spheroidal structures. The amygdules which commonly occurr on the margin of the spheroids, may consist of either quartz or calcite. Some pyroclastic material, chiefly agglomerate, was observed in association with the basaltic flows.

The green schists of the Keewatin are rocks of similar origin to the greenstone, which under the action of dynamic agencies have been transformed into hornblende schist. They occur chiefly in the country to the north of Lake Abitibi, where several masses of Laurentian granite and diorite intrude the greenstone series.

Slate and Dolomite.—Slate and dolomite are now extensively developed in the area. Outcrops of dolomite were observed at a few points on the south shore of Lake Abitibi, and a band of slate along the north shore of Lake Agotawekami, but all of these occurrences are of limited areal extent. These strata everywhere have a vertical or nearly vertical attitude, but vary in strike from nearly east and west, on Agotawekami, to slightly west of north on Abitibi.

LAURENTIAN.

Acid intrusives belonging to the Laurentian outcrop at a number of points in the country to the north and east of Lake Abitibi. These embrace a number of rock types, ranging from biotite granite through hornblende granite and syenite to diorite, and hence may be described collectively as a granite-diorite series. The marked transformation of the Keewatin greenstone into green schist, in the vicinity of these rocks, and the occurrence of granitic dykes within the schist, afford ample evidence as to the relative ages of these two divisions of the ancient complex.

POST-HURONIAN INTRUSIVES.

Here and there throughout the region, more particularly in La Reine township, the Keewatin and Laurentian are intruded by dykes of post-Huronian diabase. Since there is no Huronian present in this district, the correlation of these rocks with post-Huronian intrusives in the country to the south and west is based solely on their lithological similarity to them.

PLEISTOCENE AND RECENT.

The rock surface of this region, particularly in its northern part, is to a large extent hidden beneath a thick mantle of glacial and post-glacial materials. Boulders, gravel, sand, and till occur widely scattered over the surface of the country, in the various forms of glacial and glacio-fluvial deposition, but owing to the later deposition of lacustrine clay many of these are not exposed. From sections observed in the cuts along the National Transcontinental railway, moraines and kames appear to be the most common type of glacial deposit.

The most common post-glacial deposit is a very light blue clay, occurring in uniform beds from a half inch to three-quarters of an inch in thickness, separated by distinct layers of calcium carbonate; the latter feature can be observed in all the clay cuts along the National Transcontinental railway, in La Reine and LaSarre townships. Wherever the stratified clay was seen in contact with the underlying glacial deposits it was found to lap over them, the bedding conforming to the irregularities of their surfaces, so that, even when the underlying drift cannot be seen, its presence is indicated by the undulation in the stratification of the clay.

Economic Geology.

The construction of the National Transcontinental railway, and the consequent easy transportation facilities which this will afford, makes more valuable any mineral deposit which may be found in this region. Hence a greater number of prospectors have in recent years directed their attention to the area, and have staked claims on occurrences of various minerals, chiefly of quartz and iron sulphide.

GOLD.

No extensive deposits of gold bearing quartz have yet been located, although small, irregular quartz veins, said to be auriferous, are developed in the Keewatin dolomite; but, so far as ascertained, these are too limited in extent to be of commercial importance. Some of the iron sulphide deposits also probably carry small gold values, but, like the veinlets in the dolomite, are not of workable dimensions. It may be noted in this connexion, that while the rocks of this area are largely Keewatin, they differ from the Keewatin of Larder Lake, Porcupine, and other districts where gold has been found—in the general absence of intrusive quartz porphyry, with which the occurrence of the gold is probably associated.

Country from Lake Abitibi Eastward to Kewagama Lake.

The country to the eastward of Lake Abitibi, as far as the preliminary examination has shown, is largely occupied by rocks similar in every respect to those described above for the area examined in detail. These are Keewatin greenstone and green schist intruded locally by Laurentian rocks, ranging from granite to diorite; but, in the vicinity of Kewagama lake, a fine-grained mica schist was observed, lithologically identical with the Pontiac schist, which occurs so extensively farther west, in the neighbourhood of Lake Opasatika. The occurrence of this schist on Kewagama lake is of special interest because of its association with the molybdenite deposits of that locality.

MOLYBDENITE.

The intrusion of the Pontiac schist by the Laurentian granite of Kewagama lake was accompanied by the development of molybdenite-bearing quartz veins and pegmatite, within the margin of the granite mass, and in dykes which cut the schist. The quartz veins are most abundant in the granite that forms the large peninsula which projects southward into Kewagama lake, whereas the pegmatite occurs most extensively in a granite dyke which parallels the west bank of Kewagama river.

Prospecting during the past summer has shown nearly every exposure of granite on the Kewagama peninsula to be intersected by veins of vitreous quartz ranging from a few inches to 15 feet in width, all of which carry sparsely disseminated molybdenite and bismuthinite. A specimen of this quartz, containing pyrite, collected by Mr. Frank Johnston, in the summer of 1901, and assayed by Dr. Hoffmann of the Geological Survey of Canada, yielded 117 ounces of gold per ton. This, however, was evidently a local occurrence, since other assays of quartz procured by those interested in the property have shown no gold to be present. Development work on these veins consists entirely of small open-cuts.

A dyke of granite is exposed at a number of points on the west bank of the Kewagama river, about 3 miles north of the lake, which in places becomes pegmatitic, and contains crystals of molybdenite up to 1½ inches or more in diameter, along with bismuthinite, native bismuth, beryl, fluorite, garnet, and coarse muscovite. A shaft has been sunk to a depth of 75 feet by the Height of Land Development Company, on an occurrence of this type. At another rock exposure on the property of the same Company a mass consisting entirely of molybdenite and coarse muscovite has developed along the contact of the dyke and the Pontiac schist. This mass has an average width of nearly a foot for a distance of about 30 feet, but whether it has any continuity either along the strike or in depth was not ascertained.

SERPENTINE BELT OF SOUTHERN QUEBEC.

(J. A. Dresser.)

That portion of the Province of Quebec which lies south of the St. Lawrence river is traversed in a northeasterly direction by a series of serpentines and related rocks known as the serpentine belt. This belt is important for its production of asbestos—a large part of the world's supply—and for deposits of chromite, soapstone, copper, and antimony, which it is known to contain. The principal quarry of roofing slate now in operation in Canada and some promising bodies of marble are also intimately associated with the igneous rocks of this belt.

The general features of these rocks were first ascertained and described by Sir William Logan (Geology of Canada, 1863), and later they were further investigated by Mr. R. W. Ells (Geological Survey Reports, 1886, 1887, and 1894). In 1907 and 1909, a somewhat detailed examination was made by the writer of the portion of the serpentine belt between the Chaudière and St. Francis rivers, with especial regard to the economic resources.

During the past season this work has been continued over the section between the St. Francis river near Richmond, and the Canadian Pacific railway near Eastman. The area especially examined this season is 40 miles in length, and from 3 to 9 miles in breadth. The examination of the structure was, in places, necessarily carried over a considerably wider area.

The Eastern Townships map of the Geological Survey series, enlarged to a scale of 1 mile to 1 inch, was used as a basis in mapping. The surveys necessary to delimit the geological features, and to revise the mapping of roads and streams when necessary, were made by means of the compass and telemeter.

Messrs. John J. O'Neill and J. Alphonse Belanger were assistants in the work, and gave very efficient services throughout the season. I must acknowledge our indebtedness to Messrs. Williamson and Crombie, of the Kingsbury Lumber Company, who assisted us materially at several times.

SUMMARY AND CONCLUSIONS.

The serpentine belt, which last year was described from East Broughton to Richmond, continues across the district this year examined. With the exception of two or three localities, however, it is not found very promising for the production of asbestos. The better localities are mentioned in a later part of this report, which deals with the subject of asbestos.

Copper and nickel have been mined in certain parts of the serpentine belt within this district. The former has had an important production and seems likely to be mined again.

Chromite occurs in several places which seem to warrant further prospecting.

Slate for roofing has been quarried for many years in the Trenton formation, and other deposits in the Sillery are likely to be worked at an early date.

A marble quarry has recently been opened at South Stukely.

The igneous rocks in this district, as elsewhere in the serpentine belt, form an intrusive series whose members range from diabase to peridotite and are differentiation products of a single magma. The differentiation seems to have been produced largely by gravity, the arrangement of the rocks being in order of decreasing density in sills from the base upwards, in batholiths from the centre outward.

General Character of the District.

TOPOGRAPHY.

The district under examination lies in the hilly part of southern Quebec, generally called the Eastern Townships, and which is a part of the Appalachian mountain system of eastern North America. The topography is similar to that of the Appalachian region in general; but being only on the border of that, the great uplift, the relief is less pronounced. The hills formed by the igneous intrusions of the serpentine belt are the highest, and have generally rugged profiles; while those underlain by the sedimentary rocks have more subdued outlines. The altitude is generally between 500 feet and 1,200 feet above sea-level, but some of the intrusive hills rise considerably above this height, Mount Orford, the highest point, having an elevation of about 2,800 feet.

The most constant feature of the topography is the succession of narrow ridges and valleys running in a northeasterly direction. These are cut off at intervals by broader and more mature valleys running to the northwest, such as those of the St. Francis river at the northeast end and the Yamaska near the southwest limit of this season's work. These larger rivers carry the drainage of the entire district to the St. Lawrence river.

LAKES.

Owing to the fact that the principal ice movement in glacial times has come from the northwest, thus crossing the narrow valleys, and that the intrusions of more resistant igneous rocks have also obstructed some of them, lakes are numerous in the district. Lake Memphremagog, which is only partly within the district now being examined, is the largest. It is 30 miles long and generally less than 1 mile wide. It extends some 6 miles into the State of Vermont.

Brompton lake, the next largest, is nearly 7 miles long, and less than a mile in breadth. Besides these, there are fifteen or more smaller lakes, most of which can be seen from single points on some of the higher hills. The suitability of many of these for summer resorts seems worthy of note, since most of them are comparatively easy of access and are unoccupied.

MEANS OF ACCESS AND OTHER CONDITIONS.

Railway communication for the district is furnished by the Grand Trunk line running from Montreal to Portland; the Canadian Pacific railway from Montreal to St. John, N.B.; and by the Oxford subdivision of the Canadian Pacific railway from Eastman to Windsor Mills. The last follows, or closely parallels, the serpentine belt, as does the Bolton subdivision farther to the southward.

Public highways are numerous, and a few of them are moderately good.

Much of the area actually occupied by this portion of the serpentine belt is still densely wooded, and lumbering is accordingly carried on somewhat extensively. The less rugged country on either side of the igneous belt is more largely cleared, and has been occupied for about sixty years for mixed farming and dairying. The latter industry, for which the district is well adapted, is very successfully carried on.

The region is generally heavily drift-covered, and this factor along with its wooded character makes geological work slow and difficult

General Geology.

The highlands of the Eastern Townships comprise three main anticlinal ridges running in a northeasterly direction with two broad intervening basins, each of which is about 25 miles wide. The most westerly ridge forms Sutton mountain; the more westerly hills of Brome county, the Stukely and Melbourne ridge, the higher portion

of Wolfe and Arthabaska, and Harvey hill and the Handkerchief in the county of Megantic. The second ridge forms the Capelton and Moulton hills near Sherbrooke and Stoke mountain, and the Weedon hills farther to the northeast. The third ridge forms the boundary line between Canada and the United States for a considerable distance in the vicinity of Lake Megantic. All three of these contain important areas of volcanic rocks of the Sutton or porphyry greenstone series, believed to be of Pre-Cambrian age. These volcanics are flanked by very old sediments of Cambrian, or possibly Pre-Cambrian age.

The basins which separate the ridges are underlain by sediments of upper Cambrian and Ordovician (lower Trenton) age, with some small areas of Silurian, and one or two very small Devonian outliers. There are several intrusions of granite, believed to be of late Devonian age, in the basin between the Sherbrooke and the Lake Megantic anticlines, while west of the Sutton anticline intrusions of alkaline rocks form the well known Monteregian hills.

The serpentine belt extends along the east side of the Sutton Mountain anticline near the foot of the ridge formed by it. It consists of a series of igneous rocks which are generally highly basic, peridotite, pyroxenite, gabbro, diabase, and porphyrite, with lesser amounts of granite and aplite. The whole series is intrusive, and a part, at least, has been intruded since early Devonian time.

TABLE OF FORMATIONS.

Quaternary	Stratified sands, gravels, and clays. Boulder clay.
Devonian	Alkaline rocks of Monteregian type. Serpentine, peridotite, pyroxenite, gabbro, diabase, granite, and aplite.
Silurian	Shales and limestones.
Ordovician-Farnham	Graphitic argillites and limestone conglomerate.
Cambrian	Greywacke, purple and green slates ; red limestone ; quartzose grey schists and quartzites.
Pre-Cambrian—Sutton Mountain series	Porphyries and greenstones.

PRE-CAMBRIAN.

Sutton Mountain Series.

Probably the only rocks in this district that are older than Cambrian are the porphyry-greenstone series. These consist of granite-porphyry, quartz-porphyry, and amygdaloidal greenstones. All are much sheared and folded, and in the earliest geological work in the district were mistaken for sediments, from which it is often very difficult to distinguish them.

The porphyries form the core of Sutton mountain and the ridge which is its northward extension. On the Short Line of the Canadian Pacific railway they occupy the interval between Eastman village and South Stukely station. North of this line they soon pass under the Cambrian sediments, or give place to greenstones. They form the Green Mountain gneiss of the earlier Vermont geologists.

The amygdaloidal greenstones are so far altered that their original character cannot be precisely defined. It is certain that they are volcanic rocks, and occasionally a thin section shows the structure of diabase. In general they consist only of chlorite and epidote with smaller amounts of other secondary minerals.

These rocks form St. Armand Pinnacle and extend continuously northward to and beyond the St. Francis river. They are well shown at Foster Junction on the Canadian Pacific railway, where numerous amygdaloidal bands, apparently representing successive flows, can be seen. They make up the Chloritic Schist group of Logan, and their igneous origin was first suggested by Selwyn in 1879. A large number of the occurrences of the copper ores of the Eastern Townships are found in them.

CAMBRIAN.

The rocks of this system in the district are greywacke quartzite, grey quartzose schist, purple and green slate, and a few small occurrences of a red siliceous marble. As far as known they represent the lower portion of the upper part of the Cambrian.

These rocks occur along the western boundary of the serpentine belt separating it from the Pre-Cambrian, and occasionally are found on the eastern side. Outliers resting on the Pre-Cambrian are frequently found. Some highly altered sediments of this district have been previously regarded as Pre-Cambrian, and there is not always conclusive proof that they are not. But as no basal conglomerate or other evidences of unconformity have yet been found to mark the lower limit of the Cambrian, these highly altered sediments are provisionally included in that system.

ORDOVICIAN.

Farnham Series.

The black slates of the Farnham series—a member of the lower Trenton—are the principal rocks of this system. They are only clay slates, somewhat micaceous, generally carrying sufficient graphite or iron ore to give them a dark, nearly black colour, and are in places so calcareous as to be properly called graphitic limestones. At the base of this formation there is a well developed conglomerate composed of pebbles of the Cambrian greywacke and quartzite mentioned above in a matrix of Farnham slate. As the term slate indicates, the entire formation has been metamorphosed, and distinct cleavage at varying angles to the bedding planes has been induced.

This formation outcrops on the east, and more rarely on the west side of the serpentine belt. It is sometimes in contact with, and altered by, the intrusive rocks of that belt; but more frequently it is found resting upon the Cambrian sediments at a short distance from, and on the east side of the serpentine. It includes the rocks of the New Rockland and Melbourne slate quarries, and occurs between bodies of serpentine on Pratte's road in Stukely. In its conglomerate phase it is largely exposed about Key pond; and between Magog station on the Canadian Pacific railway and Mount Orford it is fossiliferous at Castle brook, and passes into conglomerate a few hundred feet to the westward.

Some small occurrences of massive limestone found in the district, as at South Stukely and at St. Anne de Stukely, probably also belong to the Ordovician system.

SILURIAN.

The Silurian system is of small extent in the district, but its occurrence is important, as it gives evidence that bears directly on the age of the serpentine series. The Silurian measures are chiefly grey and fawn coloured shales and limestones. These are found bordering Lake Memphremagog, and extend northward up the valley of Cherry river for a few miles.

Near the foot of Mount Orford, 2 miles north of Cherry River post-office, Silurian shales are cut by the intrusive rocks of the serpentine belt. Also at Tucks landing, 10 miles south of the district being described, Silurian strata are intruded by rocks of the serpentine series on one hand, and pass up conformably into strata containing early Devonian fossils on the other. They thus form a link in the proof that the intrusion of this part at least of the serpentine belt took place after the deposition of the earliest Devonian sediments.

DEVONIAN.

The Serpentine Belt.

The rocks of the serpentine belt are provisionally referred to the Devonian system. As previously stated, they are younger than the early Devonian sediments

in a neighbouring locality. Their highly altered character, especially their schistose structure in places, indicates that they were intruded before the close of the folding which produced the Appalachian mountain system which probably did not continue later than Carboniferous time. Moreover, they are cut by igneous rocks of the Monteregian series which are also foliated by regional compression. It is, therefore, believed that the serpentine series was intruded in later Devonian time, which is known to have been a period of great igneous activity in the region of the Appalachian uplift, especially north of New York.

The rocks of the serpentine belt are, serpentine, peridotite, pyroxenite, gabbro, diabase, granite, and aplite. The different rock types in any single locality are parts of one homogeneous intrusion. It is believed they have been separated from one another principally during the process of cooling as a result of gravitational adjustment modified by the order of solidifying of the different minerals. Thus, on the north side of the road between Racine and Brompton lake near Mud pond there is a cliff about 150 feet high, facing the northwest. At the base of the cliff the rock is peridotite, a little higher, pyroxenite, and above these, gabbro and diabase; the latter at the top becoming very acid. This is a case of an intruded sheet or sill which has forced its way upward obliquely from the southeast and later has been exposed by a fault having a downthrow on the northwest.

In other cases these igneous rocks are in the form of stock or boss, a dome-shaped body of rock formed by the cooling of a large mass of molten material after it had slowly worked its way upward into older solid rocks. Where there has been sufficient erosion to expose the igneous rocks at some depth they are found to be arranged in the same order from the centre outwards, as is found in sheets from the base upwards. This is well shown on the Montreal road, in range A of the township of Orford, a mile east of Bonelli lake, in a nearly circular area of igneous rocks varying from a mile to a mile and a half in diameter. Serpentine occurs near the centre, partially or perhaps wholly enclosed by pyroxenite. Outside of this there is an area of gabbro wrapping around a part of the pyroxenite, and the whole is enclosed by a band of diabase which completes the occurrence, and extends to the sediments all around.

Although the entire series is often, for convenience, called the serpentine belt, serpentine really makes up only a small part of it. It is not a primary rock like the others, formed from a molten mass coming from the depths of the earth, but is merely an altered phase of the peridotite which has been so formed. It occurs principally in narrow bands coating the faces of joints and cracks which have been changed by the action of surface or deep-seated waters to which they have been exposed. Relatively to the other rocks it occupies a very small area, but as asbestos occurs only in the serpentine it is nevertheless in point of value the most important rock of the series.

The granite and aplite which are parts of the same—originally molten mass or magma—have generally been intruded a little later than the other rocks, probably after they had become solid, but while they were still heated. Consequently, they are often, but not always, more sharply separated from the other rocks than those are from one another.

The serpentine belt is nearly continuous throughout this district. From the St. Francis river it forms a ridge of hills running southwesterly to a point near the south end of Long lake in Stukely, a distance of about 30 miles. Throughout this distance there are only three short intervals in which rocks of this series are not found.

The igneous rocks of this area are partly in the form of an intrusive sheet dipping to the southeast, which has been brought into more distinct relief by a fault along its northern edge. This structure gives the intrusive rocks an exposure varying from 500 feet to 2,000 feet in horizontal breadth. Vertically they are usually arranged in the order mentioned above, the serpentine and peridotite being at the base passing upwards into pyroxenite and diabase when these are present. This

fault has now been traced from the Little Nicolet lakes north of Danville to the south end of Long lake in Stukely, a distance of about 45 miles. Throughout much of this distance the fault is well expressed in the topography by a narrow steep sided valley or trench from 200 feet to 400 feet deep, which forms a rather remarkable feature of the landscape. The Canadian Pacific railway runs in this trench from the St. Francis river nearly to Kingsbury; from thence it is occupied by the Salmon river to the first range of Melbourne and farther southward it contains Gulf brook, Mud pond, and Long lake.

Besides this sheet or sill there are several larger bodies of rocks of the serpentine series in the form of stocks in the townships of Brompton, Orford, Stukely, and Bolton. The largest of these is Mount Orford, which covers not less than 10 square miles, and has a height of over 2,800 feet. It is composed at the surface of gabbro and diabase, with a little peridotite and serpentine at the western base. Another area quite as large, but of less height, lies between Brompton lake, Little Brompton, and Key ponds. It contains considerable areas of peridotite. Other occurrences are Carbuncle, Bare, and Bald mountains, which are made up mainly of the more acid rocks of the series.

ALKALINE ROCKS.

Alkaline rocks are found about 2 miles east of the village of Eastman, where a shallow cutting of the Canadian Pacific railway has exposed them for a distance of 200 feet. The exposure is surrounded by drift, but a dyke apparently from this mass, cuts the diabase of Mount Orford a couple of hundred yards away. The rocks consist of camptonite, nordmarkite, and a variety of monzonite. They form a breccia with neighbouring sediments similar to some described by R. Harvie in a recent paper to the Royal Society of Canada.[1]

The rocks are undoubtedly connected, in origin, with the Monteregian hills, and are interesting as occurring 20 miles to the eastward of Shefford mountain which has hitherto been regarded as the eastern limit of the series. They also indicate that the Monteregian hills are later in age than the rocks of the serpentine belt.

QUATERNARY.

There is a heavy covering of surface deposits over the greater part of this district, amounting, in places, to 100 feet in thickness. In general, it consists of boulder clay at the base, overlain by stratified sands and clays apparently derived from the boulder clay by the assorting action of water in early post-glacial times. No marine or other shells were found in the stratified deposits.

The general direction of glaciation has been S 5° E, but in the valleys the striæ vary greatly in direction. Thus, on the summit of Mount Orford glacial striæ are found having a direction of S 10° E; while along the Canadian Pacific railway, at the base 1,900 feet lower, the course of glacial striæ is nearly due east and west. No very satisfactory evidence could be obtained from the striæ and scorings themselves as to the direction in which the ice moved, but from the frequent occurrence of serpentine boulders for a distance of 2 or 4 miles west of the serpentine belt, it is evident that there has been movement of ice towards the west, probably in later stages of the glacial period.

ECONOMIC GEOLOGY.

Mining in this district has not yet become a regularly established industry. Copper was mined for ten years, between 1870 and 1880, or longer, with apparent success; slate has been quarried continuously for nearly forty years, and other mineral

[1] Vol. III, Third Series, 1909-10 'On the Origin and Relations of the Palæozoic Breccia of the vicinity of Montreal.'

products have received more or less attention. These operations were all undertaken while the district was remote from railways, and access was more difficult than at present. The recent extension of the Orford and Bolton subdivisions of the Canadian Pacific railway, the removal of timber, the increased settlement, and building of roads, have so far improved the conditions for prospecting and mining as to open new possibilities for the district.

COPPER.

Copper ore has long been known to occur at several places in this district. In Orford on lot 2, range XIV; lots 3 and 8 in range F; and lots 8 and 9, range A, and in Brompton, lot 28, range IX, work was done many years ago. All of these prospects have been abandoned for 30 or 40 years, and the workings so much covered that it is not possible to form any reliable estimate of the quantity of ore they may have disclosed. The fact that immediately to the south of this district, the Huntingdon, Ives, and Lake Memphremagog mines contain, or have contained, large bodies of similar ore under like geological conditions, would seem to warrant giving some attention to the properties under the present conditions of market and transportation.

The ore is principally chalcopyrite, in some cases bornite, and occurs in diabase or pyroxenite of the serpentine belt. At Orford, range A, lot 8 has bornite disseminated in pyroxenite. In several localities, especially at the Huntingdon and other mines immediately south of this area, the ore is chalcopyrite and is associated with pyrite in pyrrhotite. The pyrrhotite bodies, judging from their distribution and the character of their boundaries, are doubtless primary segregations from the country rock, which is more frequently diabase than pyrrhotite. The chalcopyrite often seems to fill small crevices, suggesting that it has been introduced later than the pyrrhotite. Further investigation is needed, however, to prove whether or not this relation is general, and also to ascertain the relations of the pyrite to the other minerals.

NICKEL.

Nickel has, hitherto, been found in only one locality in this district, namely, on lot 6, range XII, in the township of Orford, about three-fourths of a mile east of Brompton lake. Here mining operations were begun and a smelter built about 30 years ago, but the venture did not prove commercially successful.

The ore is millerite—a sulphide of nickel. The ore body occurs along the contact of an intrusion of pyroxenite into limestone. The limestone closely resembles that quarried for marble at South Stukely. The shape and size of the ore deposit could not be ascertained in the present state of the workings. Millerite, wherever found on the dump, is in crystalline calcite; but the locality having long been noted for the excellent specimens of several rare minerals that it affords, the dump has been so thoroughly picked over by mineral collectors that specimens of millerite are now exceedingly rare. The other minerals noted are chrome garnet, pyroxene, chromite, and calcite.

Mr. R. P. D. Graham, lecturer in mineralogy at McGill University, who spent some time at the locality during the past summer, has kindly undertaken to make a mineralogical study of the group of minerals obtained here. The results of Mr. Graham's investigations will appear in a later report.

CHROMITE.

No mining of chromite has yet been done in the district. The ore occurs, however, on lot 21, range VI, Melbourne, where a little prospecting was done many years ago. It is also found near the west side of Key pond in range XII, lots 3 to 8, of Orford, in a band of rock intermediate in character between peridotite and pyroxenite. The rock with enclosed masses of chromite can be traced northwards for at least 1½ miles. The area seems to be well worth prospecting.

Some chromite has also been disclosed by Mr. John McCaw, near the Brompton Asbestos mine, some 10 miles northwest of this location. As in other parts of the serpentine belt, the chromite is found in both of the localities in the outer part of the serpentine or peridotite portion of the intrusion where the rock contains a rather large proportion of pyroxene, and so is approaching a pyroxenite in composition.

ASBESTOS.

New Developments.

Since the issue of the Annual Summary Report for 1909, there has been considerable new development in the asbestos producing district at the north of the area described in this report. New concentrating mills have been completed and put into operation at the Bell, the Jacobs, and the Black Lake Consolidated Mines. The maximum capacity of these mills is from 800 tons to 1,000 tons of rock per day. The B. and A. Asbestos Company at Robertson, and the Berlin Asbestos Company near Leeds station, have built 4 cyclone mills which are also in operation on their respective properties; while the Belmina Consolidated Company, having acquired the property formerly owned by the Asbestos Mining and Manufacturing Company at Chrysotile. has re-equipped the mill and mine, and has renewed operations in both.

The Thetford Asbestos syndicate of Montreal has recently done some substantial development on lot 24, range A, Coleraine. A pit 60 feet by 50 feet has been carried to a depth of 45 feet. As far as could be judged from the walls, the rock carries a workable quantity of asbestos, an appreciable portion of which is crude. There is a boss of granite near the pit, and exposures in the vicinity show asbestos at numerous points, over an area of some 10 or 12 acres.

The present equipment consists of a cable derrick, a hoist, one steam drill, two pumps, and a 65 horse-power boiler; but an adequate mining and hoisting equipment is expected soon to be installed, and a concentrating mill built. The right-of-way has been obtained for a tram-line to connect the property with the Quebec Central railway, less than 2 miles distant.

The property is situated near the eastern side, and in the northern part of the serpentine area, which contains the principal mines of Black Lake.

Asbestos is reported to have been discovered in commercial quantities on lots 2, 3, and 4, range B, Coleraine. There was no opportunity found during the season to verify the report.

One of the most important developments for the asbestos industry, however, is the establishment by the Asbestos Manufacturing Company of large works at Lachine, Quebec. This plant—the only one of the kind in Canada—is designed to manufacture all classes of asbestos goods. When completed, the factory will have a capacity to consume about 1,000 tons of asbestos fibre per month. The plant was built by and is being operated under the management of Mr. G. R. Smith, long the manager of the Bell Asbestos mine. A more complete description of the plant and process will be given in a later report.

In the district examined this season few occurrences of asbestos have been found. On lot 22, range VI, Melbourne, about 100 feet south of the Melbourne slate quarry, a small pit was sunk some 35 years ago in the dump, of which there is a small amount of fairly good milling rock. The surrounding rock is drift covered, and the pit or shaft is partially filled with debris. It is locally reported that a small shipment of crude asbestos was made from these workings by the operators of the Melbourne slate quarry about 1876, and which was probably the first asbestos shipped from Canada.

Near Key pond some prospecting and development was done by Mr. R. H. Fletcher of Sherbrooke and others during the past season, but no very definite results were obtained.

The principal development of the district has been made by Mr. John McCaw on lot 26, range IX, Brompton township, near Brompton lake. On this property, which was somewhat extensively prospected some twenty years ago, work was resumed in the spring of 1910.

Asbestos is exposed in pits that have been opened in different parts of the property, over a distance of half a mile. In general, it may be said that the contents of the wider veins are usually hard and brittle, but that the smaller veins contain a quality of fibre that may be used. More complete development of the property probably awaits better facilities for transportation.

A little slip fibre has been obtained in the first range of Stukely, south of Long pond.

Except in the localities mentioned the rock of this district usually contains too much pyroxene to yield an asbestos-bearing serpentine.

MARBLE.

The only marble quarry in operation at the present time in the district is one which has recently been opened by the Dominion Marble Company (R. T. Hopper, Montreal, President), on lot 8, range II, South Stukely. The marble is white, with light shades of green and red in occasional bands. The green colour seems to be due to minute scales of sericite, partially chloritized; the red or pink probably to traces of iron oxide. There are few quartz veins or other features to injure the quality of the rock.

The marble rests upon, or in close association with, greenstone schists, the contact with which is drift covered. As well as could be ascertained from a few exposures, the bed of marble has a surface area of about 800 feet by 500 feet. Borings, made by the Company to a depth of 125 feet, are said to have yielded cores of good marble to that depth.

The property has been developed by means of a pit about 50 feet square, and was 30 feet deep on the first of September. The equipment consisted at that time of one boom derrick, one bar drill, and three channelling machines. Power was furnished by one 60 horse-power boiler. A spur line of railway to connect the quarry with the Canadian Pacific railway at South Stukeley, 1¼ miles distant, was begun later in the season.

The general character of this marble, and its position relative to the greenstone shict, are apparently the same as that of the quarries of the Vermont Marble Company at West Rutland, Vermont. The latter is stated in the report of the Geological Survey of Vermont for 1903-4, to contain fossils of Chazy age. No fossils could be found at South Stukely, nor other evidences to indicate the age of the rock with any degree of certainty. This, and a few smaller areas in the neighbourhood, are the only occurrences of this rock yet known in the Eastern Townships.

A red and white siliceous marble occurs at several places in the Cambrian formation, apparently interbedded with the purple slates. In range F of Orford, near Pratte's road, a body of such marble intruded by serpentine was worked for a short time several years ago. The quantity of marble was insufficient, the serpentine intrusion cutting it off at a shallow depth.

Similar rock without the serpentine intrusion is found in the Cambrian at the Kingsey slate quarry in the county of Drummond, 6 miles north of Richmond. Another occurrence of the same character, but probably underlain by serpentine, is found on lots 2 and 3 of range XI of Bolton. Each of these occurrences is some 800 feet long and from 100 to 200 feet in horizontal breadth. They are somewhat siliceous, especially around the edges, and resemble some phases of the red sand rock of northern Vermont. This is interpreted by Vermont geologists as a silicified limestone of Cambrian age.

It would seem advisable, especially in view of the present state of the Canadian market for marble, that these two occurrences should be further examined, since the mineral statistics for 1908 show that $287,587 worth of marble was imported into Canada during that year.

SLATE.

Slate of good quality both for roofing and other purposes occurs in several places in the Ordovician and Cambrian strata adjacent to the serpentine belt. In a number of these places quarries were opened between thirty and fifty years ago, but most of them have long since been closed from one cause or another, principally, it would appear, from an insufficient market at the time they were operated.

At the present time these conditions have apparently changed for the better, and the slate deposits might properly receive renewed attention.

The imports of slate into Canada for the year 1908 are stated by Mr. J. McLeish, Chief of the Division of Mineral Resources and Statistics of the Mines Branch, Department of Mines (Annual Report 1908), to have a value of $131,069; while the slate produced in Canada during the same year, all of which came from this district, is valued at $13,496.

Ordovician Slates.—The Ordovician slates occur in the argillaceous parts of the Farnham (lower Trenton) formation. They are dark, or bluish grey in colour, and have an excellent cleavage, nearly vertical, which may be at any angle to the bedding planes.

These slates have been quarried at Danville, Corris, Brompton, Melbourne, and New Rockland. The last mentioned quarry is the only one at present in operation in eastern Canada. The slate produced is of excellent quality.

The quarries at Corris, Melbourne, and New Rockland are situated so near the contact of the slates with an intrusive sheet of peridotite and serpentine as to be within the zone of alteration thus produced. The nearness to the serpentine is both a favourable and unfavourable factor. Outside of the zone of contact metamorphism the slate is soft, and lacks the strength that makes it especially valuable when slightly hardened by the intrusion; but within the contact zone, quartz veins, or flints become more numerous as the serpentine is approached, and thus tend to lessen the value of the slate. Very near the contact, too, the slate becomes a fine hornstone, too hard to be well worked; and it is then said to be sharp. The part of the rock of greatest value seems, therefore, to be near enough to the contact with the intrusive rock to secure strong slate, and far enough from it that the spaces between the flints are so large as to be worked advantageously.

The other features that injure the slate are oblique cleavages called slants, and shattered bands known as posts. These depend on mechanical deformation, and may be connected with the intrusion of the serpentine. At the Melbourne quarry, dykes of pyroxenite strike off from the intrusive rocks for 40 feet into the slate.

In its original composition, the rock may have been largely made up of good material for slate, except near the bottom of the slate beds where the basal conglomerate is found. Slabs taken from the lowest level at the north side of the main pit at New Rockland show pebbles of Cambrian sandstone and quartzite, and indicate that the bottom of the slate has there been reached.

The New Rockland quarry has been operated almost continuously since 1868. During the past eight years it has been worked by Messrs. Frazer and Davies under a lease from the New Rockland Slate Company. Some 35 men are employed, two steam drills and three derricks are in operation, steam and water-power are used. Only roofing slate is now made. The average output probably somewhat exceeds that of 1908, quoted above.

The quarrying is done in open pits, the rocks being cut down in benches. The rock is first assorted in the pit, and that suitable for splitting is hoisted and sent to

the splitting sheds. There, it is cut, split, and trimmed to the sizes required, or to which it is best adapted. The usual thickness is $\frac{3}{16}$ inch, and the superficial sizes vary from 12 inches by 24 inches to 6 inches by 12 inches. While working on higher levels in a deep pit, the waste rock is allowed to accumulate to some depth in the bottom, in order to lessen the loss from breakage of good slate by falling into the pit after blasting. During winter it is an advantage to have as little of the walls exposed to the frost as possible, since the slate, once frozen, becomes valueless if it is not split when frozen. The waste rock is, therefore, removed somewhat irregularly.

Cambrian Slates.—The Cambrian slates are green and reddish or purple in colour, and where there is a mingling of these colours a handsome mottled slate results. The green colour, in all cases seen, is that known as the ever or unfading green. The slates of this formation, as far as known, have not been influenced by the action of igneous rocks. They split less smoothly than the dark slates just described, having a coarser texture, and are frequently not as strong.

The quarries that have been opened usually show large bodies of slate free from quartz veins, and sometimes having different colours in different parts of the same pit. A few buildings in the district have roofs on which these slates are said to have lain for 50 years without change of colour or serious breakage.

Very similar slates are quarried at Fairhaven, Vermont, and are the principal variety produced in the large slate industry of that State. The manner of dressing the slate there is different from that at New Rockland, probably because of different market conditions. At New Rockland thin slates $\frac{3}{16}$ inch are generally used, while at Fairhaven the purple, green, and mottled slates are split in thicknesses ranging from $\frac{1}{4}$ inch to $1\frac{1}{4}$ inches. The price varies with the thickness, an increase of about $2 per square being allowed for each additional $\frac{1}{4}$ inch. Besides being cut to proper sizes, and split to the required thickness, the slates are bored for nail or bolt holes, and the holes are counter sunk, for which an extra charge is made. These heavy slates are said to be used principally for roofing on large steel buildings of the class now being built in the larger cities.

Slate of this quality has been opened at several places in and near this district. Green slate occurs three-fourths of a mile south of New Rockland quarry; purple and green at the Kingsey quarry, 6 miles north of Richmond, also in Brompton southeast of Mud pond, and at other places in the Eastern Townships.

Prices.

Roofing slate is bought and sold by the square, that is sufficient slate to cover 100 square feet after allowance has been made for all overlapping. A square of slate $\frac{1}{4}$ inch in thickness weighs upwards of 1,000 pounds; hence the thicker grades weigh a ton or a ton and a half per square. The present prices in New Englad for slate of good quality range from $6 to $12 per square, according to thickness. In Canada most of the slate is made into the lighter or thinner grades, for which the prices are a little below those obtained in New England.

NATURAL GAS NEAR ST. HYACINTHE.

According to instructions received from the Director, a few days at the end of July were spent in examining a locality in the county of St. Hyacinthe, from which natural gas had been recently reported. The boring by which the gas was found is located $7\frac{1}{2}$ miles north of St. Hyacinthe, in the parish of St. Barnabé, range St. Amable north, lot 164. Here gas was struck at a depth of 1,860 feet, according to the driller's log.

The boring was made by Mr. W. H. Lauffer, of the firm of Ryan and Lauffer, Chatham, Ont. The equipment employed was a Standard drilling rig, a percussion drill operated by steam power obtained from a 25 horse-power boiler. The boring, which has been carried to a depth of 1,800 feet, is encased with pipes of 10 inch, 8 inch, $6\frac{5}{8}$ inch and finally 2 inch diameter. The well was capped, and a steam gauge applied

which registered somewhat above 220 pounds pressure—the limit to which the gauge was graduated. The pipes were not then packed, and there was still some leakage of gas. The gas gave very little odour. There were no facilities for measuring the flow or for burning the gas.

Geological Conditions.—The surface of the district is nearly level. The immediate location of the well is on a low swell between the Yamaska and Salvaille rivers, which run in parallel courses towards the north. The interval between them is 5 to 6 miles, and the elevation varies quite regularly from 95 or 100 feet along either river to 115 feet in the central part near the gas well. The drift covering is very deep over the entire district, and rock exposures are rare. The records obtained from numerous shallow wells across this area gave the depth of the drift as 95 feet to 100 feet. The differences in elevation of the land surface may, therefore, agree with the rock surface, but this is by no means certain, and they are not great enough to be very significant features.

Five miles northeast of the boring, the Yamaska river takes an abrupt turn to the west, and thence joins the Salvaille. At this bend of the Yamaska, nearly opposite the entrance of the Chibouet river, rocks are exposed for about one-fourth mile. These rocks are shales of Hudson River age. They strike 7° to 10° east of north, magnetic, and form a very distinct anticline, having a steeper dip on the southeast. The ESE dip as measured is from 15° to 23°, while that on the WNW is generally 4° or 5°. This would place the St. Barnabé boring on the west limb of the anticline if there are no other folds in the drift-covered interval. There is also a pronounced pitch of 10° to 15° to the northward in the direction of the strike at this place. I could find no other exposure between the Yamaska and Salvaille rivers for 12 miles to the south. There is then a suggestion of a dome in the rocks 5 miles wide by 12 miles or more in length, but the evidence is far too slight to be conclusive.

The gas was struck at a depth of 1,860 feet in a band of rock composed of dark shale, crystalline calcite, and quartz. The boring was extended 20 feet deeper without noticeably increasing the flow of gas. Consequently, it seems probable that the band of rock containing calcite and quartz carries, rather than covers, the gas, and that as these are secondary minerals, it is a fracture zone in the dark grey shales which form compact beds above and below it.

The log of the well has been handed to Mr. E. D. Ingall; who has charge of the collection of boring records throughout Canada for the Geological Survey. A discussion of the horizons passed through, and an analysis of the results obtained, will be given in Mr. Ingall's report in this volume.

Discovery and Ownership.—The discovery of gas in St. Barnabé was made under circumstances that are rather unique. Mr. Henri Grenon, a farmer of St. Barnabé, having seen natural gas used while on a visit at Tilbury, Ontario, decided to look for some in his own locality. He organized La Compagnie Gaz et Petrole, St. Barnabé, Comte St. Hyacinthe, under a provincial charter, with a capital of $20,000. The president is S. Girard, and the secretary, Jos. Langevin. One hundred and nine shares were issued, and were subscribed for chiefly by farmers of the locality, leases were obtained on 7,000 acres, and contract for drilling was made with Messrs. Ryan and Lauffer, Chatham, Ontario.

The boring was located by the directors of the Company on the information that gas had been found (apparently in the soil), on this farm 70 years ago when a well was being dug for water.

Since the discovery all the leaseholds and other property of the Company have been sold to a Montreal syndicate at a substantial profit.

Borings have been made in the district during the past two or three seasons by the Quebec Fuel Company, and the Sherbrooke Oil and Gas Company, but the results are not yet made known.

RAISED BEACHES OF SOUTHERN QUEBEC.

(J. W. Goldthwait.)

Six weeks of the summer of 1910 were spent by the writer in the lower St. Lawrence valley, investigating the records of the late glacial or Champlain submergence, and of differential uplifts and subsidences since that time. Mr. William H. Weston, Jr., and Mr. Warren P. Smith, were engaged throughout the season in leveling, to determine the altitudes of the raised marine beaches at selected localities, and to aid in other ways in the exploration and surveying of the ancient shorelines The area covered by this field work includes the south shore of the St. Lawrence river from Matane, about 225 miles northeast of Quebec, southwestward past Quebec to Montreal, and thence southward to the Vermont and New York State boundaries. Work extended inland at each place somewhat beyond the position of the upper limit of marine submergence. Although the plans for this work contemplated a study of features south of the river only, it was found desirable and practicable to visit the north shore at Tadoussac, Murray Bay, and in the vicinity of Quebec. Work was begun on June 29, and ended August 6.

Problems Investigated.

The subjects to which attention was chiefly directed were these:—

(*a*) The outline of the St. Lawrence estuary during the stage of late Glacial or Champlain submergence, from the head of the Gaspé peninsula southwestward to the north end of Lake Champlain and the borders of the Adirondack highlands.

(*b*) The topographic expression of ancient beaches marking this Champlain shore, and its bearing upon the question of how promptly the region emerged from the sea after the ice-sheet had retired from the valley.

(*c*) The determination of altitudes of the highest marine beach, in feet above mean sea-level, at as many localities as practicable. This involved the correlation of beaches at different localities, and led to conclusions regarding the evenness of post-Champlain uplifts in this region.

(*d*) The beaches below the highest marine shoreline, formed during the post-Champlain emergence. Special attention was given to the question whether certain lower beaches register pauses between repeated uplifts, or whether the uplift was steady and uninterrupted.

(*e*) Marine fossil shells in the Champlain sands and clays, and their bearing upon conditions prevalent during the Champlain submergence.

(*f*) The discovery, exploration, and measurement of a great sea-cliff and terrace which borders the south shore of the St. Lawrence east of Quebec. The significance of this prominent shoreline as a record of excessive marine encroachment led to new conclusions regarding the number and character of post-glacial coastal movements in this region.

The information gathered along each of these lines of inquiry will be presented in outline under the several headings which follow.

THE CHAMPLAIN ESTUARY.

While it was impracticable to trace the shoreline of the ancient estuary continuously along the south side of the St. Lawrence for the 400 miles between Matane and the New York frontier, both because of the great length of time that

would have been required and because of the obscurity of this beach for long distances, the shoreline was located at points sufficiently near to one another to allow the mapping of the approximate position of the whole, as well as to indicate what portions of the ancient coast had simple outlines and what portions were ragged.

From Matane southwestward nearly to Quebec the line which marks the limit of marine submergence runs nearly parallel to the present shore and at no great distance from it. The highest beach is nowhere more than 5 or 6 miles inland, and, on the other hand, there is no place southwest of Matane where the modern shore has been cut back beyond the position of the ancient one. Through nearly the entire distance the Intercolonial railway affords easy access to the highest beach, passing at several places within a mile of it, and crossing it at Rivière du Loup and at Ste. Flavie. At other places, especially southwest of Montmagny, the old shoreline lies 3 miles or more to the south of the railway. Along the north shore of the St. Lawrence the highest shoreline lies on the foothills of the Laurentian mountains within a very short distance of the river. The contrast in character which one sees between the north and the south shores of the modern St. Lawrence is simply a repetition of the contrast between the ancient shores; the north shore was bold and ragged, with many headlands and indentations; the south shore was comparatively straight, though broken here and there (as between Bic and Trois Pistoles) by long reef-like islands.

From Montmagny, where the modern shoreline bends westward towards Quebec, the ancient shoreline maintains its southwestward course, passing through St. Gervais and St. Anselme (20 miles southeast of Quebec), and approaching the line of the Grand Trunk railway near Ste. Julie, in Somerset. The railway follows the inner border of the once submerged region, from Ste. Julie southwestward past Arthabaskaville to Warwick, where it passes through a gap in the hills to the higher region outside. From here on the old shoreline is more irregular, and distinct traces of it are hard to find. It probably crosses the Central Vermont railway just east of Granby, and the Canadian Pacific railway near West Shefford, continuing southwestward with broken outline past Frelighsburg to the Vermont line

On the west side of Lake Champlain the shoreline returns across the boundary a few miles southeast of Covey Hill village, and passes westward with gentle curvature past Franklin Centre, entering New York again not far from Herdman.

On the north side of the St. Lawrence, between Quebec and Montreal, the highest shoreline has not been traced. From the descriptions and data of Dawson and Chalmers, however, it is evident that it lies rather far inland, and enters the Ottawa valley a considerable distance north of Montreal.

The broad lowlands south, west, and east of Montreal have sometimes been called the marine plain of the St. Lawrence valley. That this was indeed the floor of the sea at the close of the ice age none will deny. The isolated mountains which rise conspicuously from the plain—Mounts Royal, Bruno, St. Hilaire, Johnson, and Yamaska—were undoubtedly islands surrounded by deep water. Yet the flatness and smoothness of this plain and its wide extent appear to be due not so much to the smoothing of the sea-floor by long continued sedimentation upon it as to the development in pre-glacial times of a wide plain of denudation. The boundaries of the plain correspond closely with the outer limits of non-resistant Ordovician slates and shales. The shoreline topography at the borders of the plain, moreover, is so obscure and expressionless that submergence lasting long enough to allow such complete flattening of the valley floor by wholesale accumulation of clays seems contradictory. Granting that the sea-floor may constitute a more apparent record of the former submergence than the faint beaches which delimit it, one is still inclined to look upon the phrase marine plain as inappropriate in this case.

TOPOGRAPHIC CHARACTER OF THE HIGHEST MARINE SHORELINE.

The writer entered upon the field work with some expectations as to the character of the highest marine beach. Experience with the strong wave-cut terraces and cliffs of the extinct Lakes Algonquin and Nipissing[1] had suggested that here in the ancient St. Lawrence estuary, with greater depth of water and equally severe exposure to storm winds, the marine shorelines would be definite, pronounced features, visible from a distance, and at favourable places imposing in strength. This expectation was supported also by descriptions by earlier investigators in this field, both in printed form and in manuscript notes, in which distinct terraces were noted at many places. The first view of the field from an east-bound train on the Intercolonial railway out of Quebec seemed to meet the expectation, for distinct lines of rocky cliffs could be seen running horizontally through the woods along the northern slope of the line of hills that looks out over the marine plain. A very few days of detailed work on the ground, however, served to correct what proved to be a complete misconception; and as the season's work continued it became more and more evident that the highest beach, and indeed all the raised beaches except one within 20 feet of the present sea-level, are usually very weak, and often entirely without topographic expression.

A conspicuous shore terrace, marking approximately the upper marine limit, was found at the mouth of the Saguenay river at Tadoussac. This, however, is plainly a delta top, constructed by the accumulation in deep water of vast quantities of river-borne sediment at the mouth of the long fiord. No sign of wave cutting or cliffing near this delta could be found. Similar terrace-like tops were found at the debouchures of other important tributaries of the St. Lawrence, *e.g.*, at Rivière du Loup, and at Matane. With the exception of delta-surfaces like these no distinct shore terraces could be found at the upper marine limit.

Here and there terraces of other than littoral origin were found, so near the supposed altitude of highest submergence that close scrutiny was needed to make clear the fact that the bench and cliff had not been fashioned by wave action. Often this proved to be a bench of weak slate, outcropping along the strike and nearly horizontal. With few exceptions such slate benches lack even a thin covering of wave-washed material; moreover, similar benches may be found at various altitudes well above the true marine limit. It is true, however, that waves cutting against a slope of crumbling slate construct a thin beach of slivers, splinters, and finer fragments, which after long exposure to decay might appear to be too full of clay and too obscurely stratified to indicate littoral origin. Yet, granting that some of these slate benches near the accepted limit of submergence are wave-cut forms, and not merely outcrop benches, the fact remains that these benches are weak and obscure. They cannot be traced more than a few hundred yards, and the escarpments behind them are seldom so steep or continuous as to draw attention to them from a distance.

Still another pseudo shore terrace is found in border drainage channels, where a river running along the edge of the ice, against an exposed hillside, carved a portion of its bed and outer bank out of the soft drift that underlay the slope. A striking example of this, to which attention has been drawn by the manuscript notes and measurements of the late Dr. Chalmers, was visited at St. Simon. The terraces here occur in a recess behind a long line of hills, which in Champlain time constituted an island that fringed the shore for several miles. Three or four very distinct terraces can be seen from the railway, along the south side of this recess, in a situation where wave action must obviously have been very weak, because of the almost complete enclosure of the recess by the island. If waves had been able to cut distinct terraces on this protected shore behind the island, they would certainly have cut much stronger terraces and cliffs on the north or seaward side of the island; and yet, although the declivity of the latter, and its rock structure, are equally favourable to

[1] See Memoir No. 10 of the Canadian Geological Survey, 1910.

cliff-development, no wave-cut benches whatever occur there. The upper marine limit is marked by a faint beach, or rather belt of gravel, above which there is no sign of wave work. The upper marine limit thus faintly yet satisfactorily marked was found by leveling to harmonize with expectation based upon previous measurements at other localities. The terraces in the recess behind the island, which Dr. Chalmers measured in 1907, do not harmonize in any case with measurements elsewhere on the highest beach, made either by him or by the present writer. The topographic surroundings of these rejected terraces, while such as to preclude their origin by wave work, make it quite probable that they are marginal drainage channels.

Contrary to anticipation, therefore, the highest marine shoreline was found never to consist of a wave-cut terrace and sea-cliff, but generally of a low beach. Here and there, at exposed points on the ancient shore, where the original declivity was favourable and the local supply of shingly beach material was abundant, one can find beach ridges with rather distinct crests and back slopes, or topographic features still more peculiar to littoral agencies, such as hooks, overlapping spits, or pocket beaches. These, while distinct, are delicate, and when traced for short distances along the extinct shoreline, fade away against a slope whose declivity or structure prevented effective wave work. In few places have favourable conditions at the highest level of submergence conspired to promote the building up of a really strong beach. At Bic the presence of thin-bedded sandstone and conglomerate in place of the usual crumbling red slate afforded coarse gravel, out of which a fine series of beach ridges was constructed. At Murray Bay, where the glacial drift which covers the hillsides was full of hard crystalline stones, the highest beach is a well-marked ridge of gravel. And at Ste. Gervais, near Quebec, wide exposure, and a gently sloping coast oblique to the dominant storms, permitted the building of a typical line of overlapping spits, which can be followed for 3 or 4 miles towards St. Anselme. These are the only localities east of Montreal where beaches were found which equal in strength the beaches of the extinct great lakes Chicago, Algonquin, and their contemporaries. At Covey hill, near the New York frontier, an unusually fine series of beaches was built during the emergence of the region from the sea, because the gently sloping hillsides which face out over the wide, flat plain are abundantly coated with bouldery drift that is full of slabs and discoidal stones of Potsdam sandstone. The distinct imbrication of these slabs in the beaches, where the structure is exposed in cross-section, and the continuity of the ridges for long distances, fully convince one of their littoral origin, in spite of the contrast between such heavily built features and the obscure beaches which mark the continuation of this same shoreline over a distance of 400 miles northeastward to Matane.

The consistent weakness of this highest beach, therefore, at all points except in the few instances mentioned, where conditions were abnormally favourable, indicates that the sea stood only a short time at the highest level. An unwarping of the coast seems to have set in almost immediately upon the withdrawal of the ice sheet from it, allowing little wave action to be registered. It is not likely that the newly opened estuary was deepened by subsidence just after the ice sheet retired, and before the elevation of the highest beach began. Besides objections on the ground of isostacy, which seems to require greatest submergence during the deepest glaciation and emergence following close behind the thinning and disappearance of the ice sheet, there is the objection that such a reversal of movement at the stage recorded by the highest beach would have involved so long a period of time that the sea would have left a stronger record of its work along the line of highest marine submergence than is actually there. This objection gains added weight also from the consideration of the topographic strength of shorelines on a slowly subsiding coast—a subject to be discussed on a later page. The demands of isostacy, and of shoreline morphology, agree in showing that regional uplift came as a prompt response to the withdrawal of the ice sheet.

ALTITUDES OF THE HIGHEST MARINE BEACH.

The altitude of the highest shoreline was obtained at over twenty localities. Care was taken to make these measurements accurate. A German pocket level of the pattern used in the topographic work of the Survey was found to give highly satisfactory results. Small errors may be allowed for bench marks at railway stations, as given in White's Altitudes in Canada. An error, seldom if ever amounting to more than one foot, is involved in the leveling from bench mark to destination. Moreover, in selecting the point at the crest of the beach to be leveled, some allowance has to be made for the original variation in height to which the beach was built up. Combining these sources of error we may look for discordances of several feet, say 5 to 10 feet, between measurements at neighbouring localities. A comparison of measurements on this basis, roughly made during the progress of the work, and more carefully made since the completion of it, shows almost complete harmony between the measurements. In other words, the variations in altitude, with few exceptions, prove to be highly systematic, and to indicate a regional upwarping of great regularity, unbroken by dislocations, or excessive uplifts of a local nature.

The method of identifying and measuring the altitude of the highest beach was briefly this: let us suppose that we have already measured the altitude of the beach which appears to be the highest one, at two localities in the neighbourhood. From these two measurements we have already figured out the tilt rate of the highest beach, that is, the number of feet which it rises in each mile in a given direction as a consequence of the differential uplift it has suffered. Knowing the distance from the last locality to this one, we have also figured out the exact altitude at which we expect to find the highest beach. At the railway station we set the aneroid barometer according to the altitude given in White's Altitudes. Using some judgment as to the most accessible slope where the highest beach may fairly be expected to be distinguishable (with due consideration for declivity, exposure, and rock or drift structure), we explore the ground near the predicted altitude. Careful search up and down the slope usually leads to the discovery of a weak yet distinct ridge of fine gravel, the uppermost and the weakest, it may be, of several such ridges. Above it there is no sign of wave-washing, either in the shape of the surface or in the character of the soil—nothing but ledges and glacial drift. Convinced that this is the highest beach, we consult the aneroid barometer, and find that the altitude is apparently 10, 25, or even 50 feet higher or lower than we predicted it would be. Returning to the station we may or may not find that the barometer checks up. In any case, we run a line of levels from the bench mark up to the beach in question, and in most cases we find that the aneroid barometer was unreliable, and that the altitude of the beach is indeed within 5 or 10 feet of what we predicted. Thus by deliberately choosing our highest beach at an altitude which the barometer told us was wrong, we have found the beach at the right altitude. When this method of fulfilling prediction is applied with success to a series of localities in turn, one feels confidence in his correlation of the highest beach at the several localities, in spite of the topographic weakness of the shoreline.

The altitudes of the highest beach at 17 localities east of Quebec are given below:—

Matane, 174 feet.
MacNider's, 243 feet.
Little Métis, 248 feet.
Ste. Flavie, 272 feet.
Sacre Coeur, 294 feet.
Bic, 311 feet.
St. Simon, 337 feet.
Cacouna, 354 feet.

Rivière du Loup, 372 feet.
Tadoussac (delta top), 406 feet.
Ste. Alexandre, 396 feet.
Murray Bay, 433 feet.
St. Jean Port Joli, 513 feet.
Montmagny, 543 feet.
Chateau Richer, 591 feet.
St. Gervais, 623 feet.
Two miles southwest of last, 632 feet.

All measurements are referred to mean sea-level. Those at Matane, MacNider's, Little Métis, St. Simon, and Tadoussac were determined by levels run up from mean high tide mark, and have been reduced to approximate mean tide mark by rough computation. For them a probable error of 3 or 4 feet should be allowed, in addition to ordinary errors of smaller amount. In the other cases the levels were run from railway stations whose altitudes are given in White's Altitudes in Canada.

West of Quebec the identification of the highest beach was found to be difficult and at many places impossible. At Ste. Julie the highest distinct beach stands at 612 feet, but there are short belts or flattish ridges of sand and gravel farther up the hillside here, as high as 695 feet. No positive conclusion could be drawn concerning the exact position of the upper marine limit. At Arthabaskaville a distinct gravel spit was found at 593 feet. This shoreline, however, cannot be traced far in either direction. Nothing higher could be found. Beyond here the country between 400 and 700 feet is very irregular, consisting of broken lines of hills and ridges, which seem to have formed a very ragged shore when submergence was at its height, so ragged that effective wave action and continuous beach building, during so brief an interval, was impossible. At Danby flattish beach-like ridges of gravel were found at 548 feet, and at West Shefford, near the Canadian Pacific Railway station, at 490 feet. The obscurity of these fragments makes their correlation unsafe. They would require a descent of the highest marine beach from about 630 feet near Quebec to about 480 feet at Montreal. This seems to be too low, both to agree with the facts at Montreal, and to match the very clear evidence of submergence near the New York boundary.

At Montreal the upper limit of submergence has been stated from time to time by different investigators to be 470, 560, and 625 feet. The 470 foot shell deposit noted by Sir Charles Lyell, in 1841, seems unreliable as a record of post-glacial submergence, because the fossiliferous strata of gravel were said to be overlain by an unstratified formation of boulders and earth. The writer is unacquainted with the facts which led Baron de Geer to set the limit of submergence here at 625 feet. Sir William Dawson's figure, 560 feet, seems to accord better with such facts as were secured during the past summer.

A few days' search around Mt. Royal, while it revealed distinct beaches at several places, at altitudes as high as 300 feet, brought to light little satisfactory evidence of submergence at higher levels. The only place where there appeared to be a distinct boundary between the lower wave-washed slopes and the upper slope of ledge and drift is at the golf links at Westmount. Here an extensive plateau of gravel lies against the west side of the mountain. Newly dug trenches display coarse stratified gravels, to a depth of 20 feet, with boulder beds, possibly iceberg till, beneath. At the club house on the golf links the surface of this gravel plateau rises gently to a short but distinct spit, which appears to mark the limit of submergence. The altitude of this spit, determined by leveling from Westmount station, is 492 feet. The spit cannot be traced westward across the golf links, where it may have been obliterated by grading; but there is a definite steepening of the slope above this altitude, and a rather abrupt change from the sandy and gravelly soil to bouldery drift. Although the 492 foot spit at Westmount accords fairly with the measure-

ments of doubtful beaches at Ste. Julie, Arthabaskaville, Danby, and West Shefford, the following reasons may be noted for refusing to accept it as the highest beach: (*a*) its weakness; (*b*) the fact that it stands fully 60 feet below Dawson's highest shell locality; (*c*) the difficulty this involves in accounting for a high gravel plateau, which will presently be described as occurring on the flank of Yamaska mountain, 35 miles east of Montreal; and (*d*) its position between Quebec, where the highest beach is about 630 feet above sea-level, and the New York boundary, where the sea seems to have stood as high as 523 feet. One would expect the highest beach at Montreal to stand at some altitude intermediate between 523 and 630 feet, not as low as 492 feet.

Search around two of the ancient islands southeast of Montreal, namely St. Hilaire and Yamaska mountains, disclosed, in the former case, distinct beaches as high as 493 feet, and in the latter case a high terrace-like plateau of gravels, whose top has an altitude of about 575 feet. Neither of these somewhat contradictory facts can settle the question of the limit of submergence. The 493 foot beach at St. Hilaire may not mark the highest stand of the sea, and the steep ledgy slope behind and above it offers little promise of a higher record having been left. The 575 foot terrace at Yamaska mountain appears to record approximately the level of standing water when the ice sheet which had enveloped the mountain first melted away from it. While it seems probable that this body of water was the open sea, because the mountain stands far out towards the centre of the plain, the possibility of a local ice-rimmed lakelet against the mountain side cannot be denied. It seems necessary at present, therefore, to leave open the question of the height of marine submergence near Montreal, with the assurance that it was at least 493 feet, and not improbably 560 feet. Everything considered, the latter view agrees best with the facts gathered from the New York boundary southwest of Montreal.

The precipitous, thinly drift covered slopes of the isolated mountains, or ancient islands, southeast of Montreal, discourage the search for a distinct beach at those points, where ideal conditions of exposure to storm waves would otherwise lead us to look for strong beaches. The undulating topography of the region near the Vermont frontier, where the old shoreline must have turned down around the east side of Lake Champlain, is equally discouraging. It may not become possible to discover the faint winding shoreline in this region until a thorough study is made of the details of glaciation just previous to the Champlain submergence.

The facts at Covey hill, near the New York line, have already been alluded to as pointing to a submergence of more than 500 feet at Montreal. The situation is briefly this: a series of exceedingly strong beach ridges, built of slabs and discoidal stones, is found, from an altitude of about 300 feet up to 523 feet. Above this there is nothing distinctly wave-built. In the interval of over 200 feet these beaches are packed rather closely, without any pronounced, persistent gaps. There is no especially prominent ridge among them, which might be selected as a line of division between marine beaches below and lake beaches above. Since the lowest of these beaches seem surely to be marine, because they are so far below the level of marine submergence at Quebec on the one hand and the supposed marine beach at the east end of Lake Ontario on the other hand, all must be taken as marine beaches, unless some of the higher ones of the series can be found to be discontinuous around the two sides of the Adirondack highlands. This point has been emphasized by Prof. J. B. Woodworth, in his study of the Mooers Quadrangle, for the New York State Geological Survey. The altitude given by him (and previously estimated by Dr. G. K. Gilbert) for the upper limit of marine submergence at Covey hill is 450 feet. Doubt as to the horizontality of some of the highest beaches, and erroneous measurements with the barometer from a bench mark which was itself incorrect (the top of Covey hill taken as 1,050 feet) account for their error. Bench marks left at road corners in this district by topographers of the Militia Department several years ago

proved to be of very great value in the present work, making the task of leveling to the crest of the highest beach around Covey hill a rapid and easy one. It was found that the highest slab-stone beach is virtually continuous from Covey Hill Methodist church westward at least as far as Franklin Centre, a distance of 12 miles. Leveling at four places, from four different bench marks in this interval, gave these surprisingly accordant results: 524·32 feet; 523·94 feet; 523·31 feet; and 524·54 feet. The last measurement is at Franklin Centre. There can, therefore, be no question about the horizontality and continuity of the 523 foot beach along the north slope of Covey hill. Before it can be positively stated, however, that this is the marine beach, it must be traced around into the Champlain and the Ontario basins on either side, or must furnish marine shells.

As already stated, Dawson's highest beach at Côte des Neiges was 560 feet above the sea. The 575 foot terrace at Yamaska mountain seems to confirm this. It is a curious fact that a tilt line drawn from the 560 foot locality southwestward through the 523 foot beach at Covey hill passes Clayton, N.Y., at an altitude of approximately 400 feet, the altitude at which Prof. Fairchild puts the supposedly marine Oswego beach.

With due regard for unsettled questions of correlation between Quebec and Covey hill, it seems rather clear that the uplift of the Champlain, or highest marine shoreline, is greatest in the vicinity of Quebec. A profile of the upwarped marine waterplane, drawn from northeast to southwest along the axis of the St. Lawrence valley, puts the top of the bulge not far west of Quebec. This may be taken somewhat as a confirmation of Dawson's conclusion that the ice sheet was thickest near Quebec, and lasted longer there than it did either to the east or to the west of that place; for the uplift, if it consisted in the recovery of the earth from compression beneath the ice sheet, would naturally be of greatest magnitude where the overlying load was of greatest weight.

Regarding the evenness of this uplift, it may be remarked that not only did the leveling fail to disclose local vertical irregularities in the warped plane, but in many cases the successful prediction of altitude by the method described on an earlier page quite precluded the probability that post-glacial faulting, or local folding, is concentrated enough to be detected by a survey of the beaches, however accurate. In the case of St. Gervais, a line of levels was run for 3 miles nearly on the crest of the beach. It showed a variation of not over 8 feet in the 3 miles, disregarding gaps in the shoreline where spits overlapped near a deflected stream. This slight variation, moreover, was rather systematic, consisting of an increase in the height of the beach towards Quebec, as if due to the gentle regional tilting. It is of significance also that the highest beach at Murray bay matches the data from the south side of the estuary, although Murray bay is in the region of contorted Pre-Cambrian crystallines, where local orogenic movements might be looked for, if anywhere. The post-glacial upwarpings here in the St. Lawrence valley seem to have been as free from local irregularities as they were in the Great Lake region, in spite of the more varied rock-structure of southern Quebec.

The relation of this new body of data to measurements of post-glacial uplift elsewhere in the Maritime Provinces, along the New England coast, and in the Great Lakes region, is important, since it adds new light upon the extent and the shape of this comparatively recent deformation of the northern portion of the continent. A map showing isobases or lines of equal uplift over this region as a whole has been prepared in manuscript, to accompany a more complete report on the work here summarized.

LOWER BEACHES AND UNINTERRUPTED EMERGENCE.

Familiarity with the distinctly spaced shorelines of the extinct Great Lakes, and with published descriptions of the marine terraces of the St. Lawrence, had prepared

the writer for the discovery of several definite and fairly continuous shorelines, separated by vertical intervals in which good wave-built features would be absent, as if to indicate that post-glacial uplifts had consisted in a number of jerks, separated by pauses of considerable duration. This conception of things, however, proved to be quite incorrect. From the highest beach, whether at 632 feet or 174 feet, down nearly to the present shore, beaches are to be found at all altitudes, where the local conditions of exposure, slope, and detritus available for beach construction were favourable. There are no prominent shorelines among these lower beaches which are remarkable for their perfection of form or for their persistency along the shore. If there is any systematic departure from a monotonous average of form and structure it is a general increase in shapeliness and sandy structure in a descending order. The coast seems to have emerged steadily from the very first, while the waves, building spits and pocket beaches at favourable places, as the configuration of the shallowing shore kept changing, gradually produced more and more distinct beaches with the shingle and sand which they drew down the slope from beach to beach. This opinion, though formed contrary to expectation, and quite independently, agrees, I have since found, with Prof. H. L. Fairchild's published conclusions based upon the slab-stone beaches at Covey hill.

It agrees also with evidence of uniform uplift as recorded by a general discontinuity of river terraces in New England valleys, and especially on the coast of Maine.

FOSSIL SHELLS.

A survey of the raised marine beaches, strange as it may seem, does not lead to the discovery of a large variety of fossil shells. Close scrutiny of shallow roadside trenches, and occasionally of deeper excavations and natural cross sections of the marine sands, usually proved fruitless. Near the highest beach, especially, marine life seems to be almost wholly unrecorded. At lower levels, where the water was deeper at first, and the conditions better for life and for its preservation by quiet burial in clays, opportunities for collecting fossils are better. In view of the boreal character of the Champlain fauna, moreover, it seems not unlikely that at the very first, when the ice sheet had hardly retired from the estuary, the conditions for life were forbidding, if not prohibitive.

At the lower levels on the beaches and the terrace near the present shore, one is liable to be misled at first by the abundance of shells turned up in the freshly ploughed fields, and in pastures which were formerly cultivated. The common use of rock weed, and other littoral vegetation, for manure makes the presence of shells near the surface of cultivated fields of no palæontological value.

At three localities shells were found in abundance in undisturbed positions. Several exposures of clay beside the road that leads from the Murray Bay pier to the village yielded innumerable specimens of *Macoma (Tellina) Groenlandica,* and fewer *Macoma calcarea.* The best of these beds were near the upper surface of the dissected clay plateau about 1½ miles southwest of the village, at an altitude of about 170 feet.

Two miles north of Port Neuf station, about 35 miles west of Quebec, a fresh roadside trench in a wooded, uncultivated district, furnished hundreds of *Saxicava arctica (rugosa)* and a few *Macoma Groenlandica.* Among the Saxicava were a number of individuals with the valves together standing erect in the attitude of growth. The undisturbed bedding of the sand was quite clear. The altitude here, by barometric measurement from Port Neuf station, is 372 feet.

A gravel pit about a mile south of Hemmingford, near the New York frontier, which Prof. J. B. Woodworth has described in his report on the Mooers Quadrangle, was visited, and from it an abundance of Saxicava shells were gathered. As Prof. Woodworth has stated, this shell-bearing deposit is remarkable, because the complete shells, standing erect in attitudes of growth, are packed tightly between coarse gravels,

where one would expect they would have been jammed and crushed by the shifting of heavy stones during storms, and where there has been every opportunity since the sea retired for ground water to dissolve the shells.

THE 20 FOOT TERRACE AND SEA-CLIFF.

It has been stated above that from the upper limit of submergence down nearly to the present sea shore, fragmentary beaches are found at such a variety of altitudes as to indicate an uninterrupted emergence of the coast. The condition is quite different near the present shoreline. On the second day of field work attention was drawn by a steep sea-cliff and terrace behind the modern beach at Cacouna. The upper edge of the terrace at the foot of the cliff was leveled, and found to be from 15 to 20 feet above high tide mark. Although the cliff and terrace here displayed great strength, in contrast to the weaker beaches which had already been seen at higher levels, the extent and importance of it was not suspected until the following day, when a second visit to the shore of the St. Lawrence, this time at Trois Pistoles, 20 miles farther east, disclosed a similar sea-cliff and terrace, standing behind the present beach well out of reach of the waves, and stretching for miles along the coast. At Bic, 28 miles beyond Trois Pistoles, the 20 foot terrace and its great sea-cliff was found again, and from there on it became a familiar feature of the landscape. It extends, according to our observation, with fair continuity from Quebec eastward 200 miles to Matane. Beyond that point our survey did not extend. Throughout this distance the terrace maintains a fairly uniform altitude of approximately 15 to 20 feet above high tide. It rises and falls only so much as the original variation in its surface, and subsequent blurring by soil creep, wind blown sand, or alluvial wash, are sufficient to explain. From MacNider's eastward for over 25 miles to Matane the carriage road along the shore of the St. Lawrence lies upon this ancient terrace. Overlooking the road on the one hand is the steep sea-cliff, rising from 20 to 50 feet above the terrace, and extending in a nearly straight course, with no gaps except where a tributary stream passes down from the uplands to the terrace level. On the other hand, one looks down the gently inclined terrace surface, and out beyond high tide mark across wide tidal flats which form the outer continuation of the terrace. The shallow mud flats stretch offshore in places for 1 or 2 miles. At low tide one can look out across the bare mud flats to a wide expanse of shallow water that lies beyond, where the heads of many boulders rise out of the shallows. The waves have done very little work along the present high tide mark. Usually a low beach ridge, or at most a low sea-cliff not more than 10 feet high, separates that part of the 20 foot terrace which now lies above the sea from that part which is now submerged. Similar views of high cliff and broad half exposed terrace can be had at Little Métis, Rimouski, Bic, Trois Pistoles, Cacouna, Frasierville, Ste. Anne de la Pocatière, and many other places. The Intercolonial railway runs along the 20 foot terrace at the foot of the old sea-cliff for a few miles, midway between Bic and Rimouski. Just west of Sacré Cœur station the sea-cliff beside the railway, instead of being cut in glacial drift, has been cut in slate, and forms a precipice 100 to 125 feet high. The amount of wave-cutting along this ancient shoreline, judging from the great width of the terrace and the height of the cliff, must have been prodigious. In comparison with them the changes wrought along the present water's edge are insignificant.

At Tadoussac and Murray Bay, the only points visited on the north side of the St. Lawrence east of the Isle of Orleans, the 20 foot terrace was not found distinctly developed. Steep slopes, resistant crystalline rock, and conditions for delta-building may account, however, for its absence. The terrace and cliff are strongly developed from Quebec eastward for 25 miles, at least to Ste. Anne de Beaupré, and can be plainly seen for most of this distance from the car window of the electric railway. It is the only strong and persistent topographic feature of the gently sloping coast from Quebec eastward, the only shoreline that shows effective wave work.

Numerous hand-level measurements of the altitude of this terrace were made, and occasionally the more precise leveling instrument was used. The results show very close accordance in height over the distance of 200 miles. In the following list of altitudes the measurements refer to local high tide mark, as determined by a line of flotsam on the beach. This introduces into the figures an additional error, which may amount to 3 or 4 feet. In spite of this, however, the measurements at the widely separated localities are fairly accordant.

Rivière Blanche (10 miles west of Matane), 15 to 17 feet.
Little Métis (a beach), 19 feet.
Rimouski, 22 feet.
Sacré Cœur, 20 to 22 feet.
Bic, 19 to 21 feet.
St. Simon (a beach), 17 feet.
Trois Pistoles, 14 to 19 feet.
Cacouna, 14 to 21 feet.
L'Ange Gardien (10 miles east of Quebec), 14 to 16 feet.

There appear to be two ways of accounting for this strong 20 foot shoreline. It may record a pause in the post-glacial emergence, when the coast was stationary for a long time, and the waves were given the opportunity to encroach upon the land, or it may record a temporary reversal of crustal movement, when emergence ceased and subsidence set in, to be followed in due time by a re-elevation of 20 feet. In choosing between these explanations, the following points should be taken into account:—

(1) The evidence from higher beaches indicates that up to the time when the 20 foot terrace was cut emergence had been steady and uninterrupted, although amounting to 200 to 600 feet in this part of Quebec. It is not easy to see why after so great an uplift there should be a pause of such great duration as the sea-cliff and terrace demands, and why this should finally be followed by a second uplift, when isostatic balance appeared to have been gained. Would we not expect evidences of several such pauses instead of only one great pause?

(2) Waves, if given time enough, will develop and cut back a line of straight or gently curved cliffs along a stationary coast, but the length of time required for the perfecting of this process of cliff recession is greatly shortened if the coast in question is slowly subsiding. As Dr. G. K. Gilbert and others have remarked, the deepening water on a slowly subsiding shore facilitates the disposal of cliff debris, and enables waves to cut back at an abnormally rapid rate. This principle seems to account for the abnormal strength of the Algonquin and Nipissing shorelines in the Great Lake region; for each of these cliffed shorelines records a climax in the rising of the lakes from a temporary low water stage during the slow differential uplift of the outlet of the lakes. Although it has almost never been emphasized by an application to actual cases like these, the principle of slow subsidence as a cause of rapid cliff development is pretty well established, both by theory and by observation.

(3) There is independent evidence of coastal subsidence in the Maritime Provinces and New England, since the great post-glacial upwarping. While several lines of evidence, especially those which have been urged as indications of subsidence now going on, may be regarded as unconvincing if not actually unsound,[1] other evidences, such as submerged forest beds and stumps *in situ*, below low tide mark at many places on the sea coast can only be accounted for by subsidence. The evidence in hand does not make it so plain whether the sinking of the coast ceased long ago or is still in progress. Physiographic evidence near Boston, at Nantasket beach, was recently presented by Professor Johnson as an argument for the belief that there has been neither subsidence nor elevation of the coast at that latitude during the last two or

[1] See D. W. Johnson, "The Supposed Recent Subsidence of the Massachusetts and New Jersey Coasts." Science, Vol. 32, Nov. 18, 1910, pp. 721-723; and "Botanical Evidence of Coastal Subsidence." Science, Vol. 33, 1911, pp. 300-302.

three thousand years. There appears then to be no valid objection to the view that the general coastal subsidence which followed the great emergence was itself followed, at least in southern Quebec, by a slight re-elevation. The correlation of the 20 foot terrace and sea-cliff with the submerged forest beds and stumps seems to contradict none of the facts thus far presented and accepted.

(4) If the great terrace marks a stage of coastal subsidence between two stages of uplift, it agrees well with the conception of isostatic recovery from the released load of a vanishing ice-sheet. The first prompt upwarping may have been carried up the more central portions of the region too high; the reversal of movement may in turn have carried the region down a little too low; and a final elevation of 20 feet may have been required before equilibrium was fully established. A rhythmical balancing of this sort would seem to demand (*a*) rapid uplift, becoming slower and slower as the climax was reached and subsidence began to set in; (*b*) coastal subsidence, which, occupying the same length of time as the previous elevation, yet consisting of a relatively slight vertical change, would be expressed mathematically by a very much slower rate in feet per century; and (*c*) a still slower uplift, in which a period of time similar to the first and second was used up in the rise of the coast from sea-level to the 20 foot mark. Thus we would find ample explanation of (*a*) the weakness of the highest beach, and the increasing distinctness of the beaches in descending order; (*b*) the comparative strength and maturity of the 20 foot terrace and cliff; and (*c*) the lack of distinct shore topography at the present sea-level.

(5) The investigations of Baron Gerard de Geer, Professor W. C. Broegger, and others, in Scandinavia and Finland, have led them to conclusions which the foregoing ideas simply duplicate. Since the ice age northern Europe appears to have experienced two uplifts and an intermediate subsidence. At the time the ice began to disappear from the Baltic sea the land stood much lower than now—at Christiania 700 feet lower. Clays accumulated in the Baltic at this time, which contain fossils of a boreal fauna analagous to the fossils of the Champlain clays of North America. Emergence of the Baltic region set in at once, and continued so far that the land stood at a level higher than it now stands. The Baltic basin was converted into a freshwater lake of vast extent. Records of it are found in sands and clays which contain the freshwater *Ancylus* fauna. These clays fringe the coast of the Baltic up to altitudes above 100 feet. Following this emergence came a stage of coastal subsidence, during which the lower portion of the Baltic basin was again depressed beneath the sea, and deposits of clays and sands were made with a marine fauna which is known as the *Littorina* group. This subsidence is Broegger's *Littorina-Tapes* Senkung. The third movement, a re-elevation, brought the *Littorina-Tapes* shoreline up to its present level—at Christiania about 200 feet above the sea. Professor Broegger has subdivided this elevation into three parts, on the basis of distinct beaches, faunas, and archæological evidence, calling these divisions the Altere, Mittlere, and Jungere Tapeszeit. The rate of uplift is said to have been more rapid during the Mittlere Tapeszeit than in either the Atlere or Jungere Tapeszeit. This might be interpreted as an indication that at first the earth was only beginning to recover from the Littorina subsidence; in the Mittlere Tapeszeit the upward movement had become well established; and that towards the close of the Tapeszeit emergence a final balance was gradually reached.

The evidence of these three movements cited by the Scandinavian investigators consists of clays and sands containing the marine and fresh-water faunas and floras; submerged stumps and peat beds; and drowned valleys. While the shorelines marking each of the stages are definite enough to allow precise measurements of altitude to be taken (in the collecting and correlating of which data the Norwegian and Swedish Geological Surveys have made great progress) no attention has been called, so far as known to the present writer, to an abnormal strength of the Littorina-Tapes shoreline, or to extensive cliff recession at that level, as evidence *per se of* slow coastal subsidence.

The evidence upon which the corresponding stage of subsidence in southern Quebec now chiefly rests—the great 20 foot terrace and sea-cliff—is, therefore, entirely independent. It is of interest to note, also, that the interpretation of this sea-cliff as an evidence of subsidence was settled upon by the writer, without foreseeing at that time that the three-fold movement thus demanded would correspond to conclusions previously formed by European investigators.

Confirmation of the date of the subsidence in Canada, and of the correlation of buried stumps with the great terrace and sea-cliff, must, of course, be searched for before positive conclusions are drawn. It is apparent, however, from the virtual continuity of this terrace for 200 miles along the south side of the St. Lawrence, and from Quebec along the north side as far as the search disclosed favourable conditions for it, that this feature is not local. Its nearly uniform attitude throughout this distance leads to the same opinion. It seems to preclude such an idea as that the great cliff cutting is the result of a temporary raising of the high-water mark by the deflection of tidal currents consequent upon changing configuration of the coast. The results of such local fluctuations would be less uniform between the Gaspé peninsula and the head of the estuary at Quebec. It seems reasonable to suppose that an exploration of the coasts, with the terrace of submergence as the central idea, will demonstrate a stage of coastal subsidence of long duration and wide extent, separating the earlier, greater uplift from the later, lesser one. We would then be justified in subdividing post-glacial time into three parts, corresponding with the Ancylus, Littorina, and Tapes sub-epochs of Scandinavia.

Notes on Glaciation.

From such scattered, casual observations of striæ, roches moutonnées, and erratics as were possible during the progress of the work on the shorelines, where with so short a field season and so wide a field, concentration upon the problems of submergence was imperative, it is not safe to draw positive conclusions. In general, observation appeared to confirm the statements which have been published from time to time by the late Dr. Chalmers—at least in these respects:—

(*a*) East of Rivière du Loup, smoothed bosses of rock, usually of sandstone or conglomerate, protruding from the soft red slate which underlies the marine plain, seem to indicate a general movement of the ice sheet from south to north, as if this south side of the St. Lawrence, between Quebec and the Gaspé peninsula, had been glaciated from a centre on the Appalachian highlands. As a rule, however, the soft crumbling red and grey slates of this belt give little evidence of the direction of glaciation.

(*b*) The relative abundance of large crystalline boulders on the surface below the highest beach, in this region, suggests that material from the Laurentide mountains crossed the lower St. Lawrence largely through the agency of floating ice, during the later stages of the glacial period, while the coast was still submerged. The large number of these boulders on the present shore, where the tide-covered outer portion of the wide 20 foot terrace in many places is literally peppered with them, seems to be due largely to the same agency—floating ice, and not merely to the failure of the waves to remove boulders while the great sea-cliff was being eaten back.

(*c*) At a number of places near the modern shoreline, ledges were observed which have been heavily scoured and shaped by ice moving in a direction parallel to the shore. In some of these places—*e.g.*, Cacouna—the stoss and plucked sides seem to occur indiscriminately, at either end, and it is hardly possible to say whether the movement was from the northeast or from the southwest. As a rule, however, it seems to have been southwestward, up the valley. Out near Gaspé peninsula, about a mile east of MacNider's, a rocky island close to the shore exhibits typical rôches moutonnée outline, showing heavy glaciation here from about S 83° E to N 83° W (corrected).

Scoured bosses of trap rock beside the shore road, midway between MacNider's and Little Métis, seem likewise to show a glaciation from east to west.

The indications, therefore, favour the idea that the Atlantic peninsula, lying between the lower St. Lawrence, the Gulf of St. Lawrence, and the Gulf of Maine, had its own centre of dispersal, in the glacial period, and that along the south coast of the lower St. Lawrence pack ice, moving from the gulf up the valley, has been a strong factor in determining details both of erosion and of boulder distribution in the area of submergence.

On the other hand, our observations fail to confirm the view that local glaciers moved down the valleys of the du Loup, Trois Pistoles, Nord Ouest, Rimouski, Métis, Matane, and other rivers. These valleys, where they pass through the undulating uplands that border the St. Lawrence, are wide open rather than bold and deep. They lack utterly the features peculiar to valleys which have been deepened and widened by glacial action; and the terraces which occupy them are clearly of fluviatile origin. Regardless of evidences of valley glaciers in the deep fiords along the north shore of the St. Lawrence, it seems plain that the south shore was glaciated rather by an ice sheet.

TOBIQUE DISTRICT, NEW BRUNSWICK.

(G. A. Young.)

The district topographically and geologically surveyed during the field season of 1910 lies in northwestern New Brunswick and includes a tract of country about the forks of Tobique river. The Tobique flows in a general southwesterly direction, and is one of the larger tributaries of the St. John river, which it joins a few miles north of Perth.

Field work in connexion with the main control work was commenced in the latter part of May, under the supervision of Mr. D. A. Nichols. The main party arrived in the field during the second week of June, and field work continued until the end of September.

In the field the writer was assisted by Messrs. M. F. Bancroft, A. Boucher, J. L. Cavanagh, F. A. Huntingdon, D. A. Nichols, A. G. McIntyre, D. L. MacLeod, H. G. Morison and B. Rose, all of whom performed their duties in a satisfactory manner.

Means of Communication.—The district may be conveniently reached by means of the Tobique branch of the Canadian Pacific railway, which, leaving the main line at Perth, runs northeastward along the eastern side of Tobique river as far as Plaster Rock. From Plaster Rock a highway leads northward up the Tobique valley for about 26 miles in a straight line, to the forks of Tobique river. The district may also be entered by a canoe route favoured by tourists, sportsmen, and others, which follows the course of Nipisiguit river westward from Bathurst on Chaleur bay to Nipisiguit lake at the head of the river, crosses a low divide to Little Tobique lake, and continues down the Little Tobique to the forks of Tobique river. The section, under construction, of the National Transcontinental railway between Grand Falls on the St. John, and Moncton, crosses the Tobique a mile or so south of Plaster Rock.

Within the district, travel, except on foot, is practically limited to the one highway running northward up the Tobique valley, and to a number of rough portage roads running in various directions that have been cut out by lumber companies. The Tobique river and its larger tributaries can be traversed in canoes, but these streams are swift, and, except at high water stages, the load that may be carried in a canoe is very limited.

Location and Area.—The district surveyed in 1910 has an area of approximately 400 square miles. The southern boundary crosses the Tobique south of the mouth of Gulquac river at a point about 5½ miles north of Plaster Rock, and the northern boundary lies about 3 miles north of the forks of Tobique river. The western boundary, starting in the south from a point on Tobique river, in the northern part of the district, lies about 8 miles west of the forks of the river; the eastern boundary is so situated as to include, in the southeast, Long and Trousers lakes.

Methods of Field Work.—The field work was carried out with the intention of mapping the geology and preparing a topographical map on a scale of 2 miles to 1 inch, with contour intervals of 100 feet. In order to establish elevations and geographical positions, a carefully run transit-stadia line was carried from Plaster Rock northward into the district. For the purpose of primary control it was originally intended to run accurate transit-stadia lines along portage roads, that would form one or more circuits and yield a framework of approximately the same outline as that of the district. Because of lack of time, however, this plan was in part abandoned, the portage roads being but little better than very crooked paths along which the individ-

ual sights did not average much above 150 feet in length, with a correspondingly low rate of daily progress.

The main control, as made, consists, in part, of circuits of carefully run transit-stadia traverses, but mainly of compass-stadia traverses run by means of a transit, and with a number of observations for magnetic declination. Various secondary traverses run by compass-stadia-transit were also carried out, as well as plane-table-compass-telemeter traverses of main streams and the shores of lakes. Between points established as above, numerous traverses run by plane-table-compass and pacing were made, the relief, etc., sketched in, and elevations determined by aneroid controlled by a series of daily aneroid readings made at central points of known elevation.

The geological map work was carried on by the members of the party in the course of their topographic work. The positions of all rock exposures seen were noted, and their characters usually recorded by simply taking small specimens. The number of specimens so secured while large, is not excessive, since, except along parts of some of the larger streams and over several limited areas, rock exposures were rare.

Previous Work.—The district surveyed in 1910 is part of a much larger area represented on a scale of 4 miles to 1 inch by map sheet No. 2 NW, which accompanies a report on the region by Messrs. L. W. Bailey and W. McInnes.[1]

In 1905 Professor W. A. Parks examined a portion of the area mapped this past season and reported on it.[2] An unpublished, final report, in manuscript form, by Professor Parks, was placed at the disposal of the writer.

R. Chalmers,[3] during several seasons, studied and reported upon the surface geology of the Tobique and adjacent regions.

PHYSICAL FEATURES.

Drainage.—The Tobique district is situated within the broken, relatively elevated country of northwestern New Brunswick. The district is drained by the Tobique river and its tributaries. The river flows in a marked valley lying towards the western edge of the district, and extending in a south-southwesterly direction. Towards the north, the valley is comparatively narrow, varying in width from one mile to scarcely more than the breadth of the stream bed, and has, on both sides, faces rising sharply from 200 feet to 400 feet above the river, but broken by the valleys of numerous large and small tributaries. Towards the south, the river channel usually lies from 100 feet to 200 feet below the level of the broad, main valley, which extends for some miles to the westward beyond the limits of the sheet.

In the north, the constricted valley of the Tobique is directly continued northward by the valley of Nictor or Little Tobique river, and similar physical characters are exhibited by the valleys of Sisson branch coming from the west, of the Mamozekel from the northeast, and of the Campbell river from the east, all four streams uniting in the neighbourhood of the forks. Some 7 miles east of the forks, the Campbell river also forks, one branch, the Serpentine, coming in from the east, the other, known as the Campbell, coming from the south, where it heads in Long and Trousers lakes. Trousers lake is bordered on its western side by a group of high hills whose western flanks are drained into the Gulquac river, which, following a nearly due west course, traverses a marked valley, and enters the Tobique river towards the southwestern corner of the district.

Relief.—The Tobique district lies, in part, along the eastern margin of a tract of elevated, rolling country, sometimes spoken of as a tableland, that extends westward into Maine. East of this upland, the country lying towards the centre of New Bruns-

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[1] Bailey, L. W., and McInnes, W.; G.S.C., Ann. Rept., Vol. II, 1886, Part N.

[2] Parks, W. A.: G.S.C., Summary Report for 1905, pp. 115-117.

[3] Chalmers, R.. G.S.C., Summary Report for 1899, pp. 148-155, and Summary Report for 1900, pp. 151-161.

wick is much more rugged, and the physical features of the eastern portion of the Tobique district largely conform to this type.

The vertical relief of the country is considerable in amount, the Tobique in the southwestern corner of the area being only about 350 feet above the sea, while numerous peaks and ridges rise to elevations of from 1,200 feet to 2,500 feet. Towards the northwest the country is essentially a rolling upland, cut by numerous valleys and deep gullies, and having a general elevation of between 1,000 feet and 1,500 feet above the sea. Similar topographic forms are displayed in other parts of the district, but as a whole the region is characterized by the presence of sharp ridges running in various directions and rising steeply 800 to 1,200 feet above the surrounding country. These ridges, though sometimes distinct from one another, are more often grouped, as in the case of the mountainous tract lying just east of Trousers lake. A characteristic feature of the district is the presence of isolated, conical hills, whose peaks are from 300 feet to 1,000 feet above their bases. A notable feature of the district is the presence of a valley, or series of valleys, of irregular widths, running northward through the centre of the district. Perhaps the most characteristic feature of all is the gorge-like character of the various waterways, a character shared by the courses of even very small brooks.

General Geology.

At the present time it is thought advisable to offer only a few generalized remarks bearing on the geology of the district, since a large part of the field work performed by assistants has not yet been compiled.

The Tobique district includes a portion of the southeastern border of a large tract of westerly extending country that has been described as occupied by Silurian strata. This Silurian area has been mapped by various geologists as being bordered on the southeast by a belt of Ordovician strata separating the Silurian measures from Pre-Cambrian strata, which, farther eastward, are penetrated by large bodies of granite. The district also includes the northern portion of what has been called the Tobique outlier of lower Carboniferous strata. Silurian fossils have been found at several localities within the district, and others of Devonian type (Oriskany) have been found in narrow limestone beds interstratified with black slates occurring on Campbell river. The occurrence of areas of volcanic rocks has also been noted.

At the present time, the writer is unable to offer any new facts of importance regarding the general geology of the district. Over a great part of the area the strata consist of folded and faulted measures, usually greyish in colour and varying in general appearance from slate-like to coarse sandstones and fine conglomerates. At many points acid and basic igneous rocks, including rhyolites and rhyolite-tuffs, outcrop. Some doubt is felt regarding the propriety of subdividing the strata into Silurian, Ordovician, and Pre-Cambrian, as has been done by previous students of the geology of the region.

Economic Geology.

Although it has been reported at various times that alluvial gold has been found within the area under discussion, and more particularly in the bordering regions to the east and north, no evidence was secured of the presence, or of the probability of the presence of deposits of metalliferous minerals of economic importance. All the rock exposures seen, with only one or two exceptions, proved barren of any signs of mineralization, though, in one case, a very small amount of disseminated pyrite was seen. But the character of the country is unfavourable to the prospector, since exposures of rock *in situ* are, as a general rule, limited in number and widely scattered. It is possible, therefore, that, concealed by drift, there may exist gold-bearing veins, or other deposits of economic value.

As recorded by Chalmers[1] and others, colours of gold have been recovered from the gravels of various streams, though apparently never in any quantity. At different times during a long period of years, fragments of quartz, thickly impregnated with gold, have been reported to have been found, but in no case has precise information been furnished regarding the exact, or even the approximate position of the discovery.

The general lack of mineralization within the district examined during the past year tends to discourage the idea that any valuable deposit of gold occurs within the area. The existence of colours of gold in stream gravels does not, by itself, necessarily indicate the presence in the district of workable deposits of that metal, for colours of gold may be recovered from streams in districts where there is no reason for believing that gold exists in paying quantities, either in gravels or otherwise. It is possible, too, that at least in certain cases of alleged discoveries of gold-bearing quartz, some other mineral has been mistaken for gold, and it is perhaps significant regarding all such reported discoveries, that in no case was the exact point of discovery revealed.

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[1]Chalmers, R.: G.S.C., Summary Report for 1899, pp. 148-155, and Summary Report for 1900, pp. 151-161.

ARISAIG-ANTIGONISH DISTRICT, NOVA SCOTIA.

(M. Y. Williams.)

The field work of the summer of 1910 was concerned with a detailed study of a portion of Antigonish and Pictou counties, N.S., represented on geological sheets (scale, 1 mile to 1 inch) by Hugh Fletcher, and accompanying his report of 1886.

The object of the work was to determine the age and relations of the sedimentary rocks, the age, character, and relations of the igneous rocks, and with Mr. Fletcher's work as a basis, to map the area studied on the scale of ½ mile to 1 inch. In the carrying out of these plans additions were made to the base map, a careful survey was made of the iron ore prospects, and considerable work was done in connexion with the gypsum deposits.

It is a pleasure to acknowledge indebtedness to Professor Charles Schuchert, of Yale University, and to Mr. W. H. Twenhofel, Assistant Professor of Geology at the University of Kansas, for assistance and advice during the early field work. Thanks are also due Mr. George E. Corbitt for assistance in the examination of the iron prospects which are under his management.

Work in the field was begun by the writer on June 22, and continued until September 24. Field work by Mr. M. H. McLeod covered the period between July 6 and October 8. Mr. McLeod rendered valuable assistance in many ways, and took charge of the revision of the base map.

LOCATION AND AREA.

The Arisaig-Antigonish district fronts on Northumberland strait, about midway between Cape George and Merigomish harbour. The area studied extends along the coast 5 miles northeast and 5 miles southwest from Arisaig point, and about 11½ miles southeast to the Intercolonial railway, and includes the gypsum deposits south of the railway. Its area is approximately 115 square miles. The Intercolonial railway furnishes communication along the southern border of the area, while stage routes reach the interior and shore districts. Steamboat communication is somewhat irregularly maintained with Pictou and Cape Breton ports.

PREVIOUS WORK.

In Gesner's report, published in Halifax, in 1836, the rocks of Nova Scotia were classified, and those of Arisaig were included under Red Sandstone rocks. Since then Sir William Dawson,[1] Dr. Honeyman,[2] Mr. T. C. Weston, Dr. H. M. Ami,[3] and Mr. W. H. Twenhofel,[4] have done valuable work on the area, in working out time relations and structure, collecting fossils, etc. In 1886 Mr. Hugh Fletcher[5] published his report on the area. It and the accompanying maps give a careful treatment of the formations, and the general and economic geology.

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[1] Quart. Jour. Geol. Soc., London, 1845; Acadian Geol., 4th Ed., 1891, and G.S.C. reports:
[2] Trans. Lit. and Sci. Soc., Halifax, 1859; Geol. Soc. Quart. Jour., vol. 20; Trans. N.S. Inst. Vol. IV, 1878 and 1887.
[3] Trans. N.S. Inst., Series 2, Vol. I; Trans. Roy, Soc. Can., Vol. VI, 1900; Bull. Geol. Soc. Am., Vol. XII, 1901; N.S. Inst. Nat. Sci., Vol. X, 1901.
[4] Am. Jour. Sci., Vol. XXVIII, August, 1909.
[5] G.S.C., Rep. 1886.

General Character of District.

TOPOGRAPHY.

Regional and Local.—The Arisaig-Antigonish district belongs to the Cobequid plateau region of northern Nova Scotia. The central highland of the district, underlain by the Browns Mountain (Cambro-Silurian of Fletcher) formation, rises in the north and east to an elevation of from 900 to 1,000 feet above the sea. The sky-line is notably even across the bevelled strata, and only in the gorges worn by the streams do we find any great deviation from a plain. A gentle slope to the southwest is perceptible. On the northwest, along a line nearly parallel with the shore, the plateau descends to the younger formations over the fault scarp of the Hollow. In many cases the descent is very steep and the brow of the scarp very regular and clean-cut. Later erosion has given the Hollow the form of a U shaped valley, along which the streams, in many cases, flow some distance before finding a gap through the lower hills. North of the Hollow, high, well-rounded hills drop away to the shore. The lower country of the Silurian area presents a knolly aspect, while old sea-beaches, up to an elevation of 120 feet, occur along the shore.

On the east and south the plateau descends rather suddenly to the rounded hills and flat lands of the Windsor (Carboniferous Limestone and Conglomerate of Fletcher) group area. Karst topography, with ponds, sink holes, and interrupted drainage, is characteristic of the limestone and gypsum areas on the south. West of James River station, the railway follows a narrow valley floored by Arisaig (Silurian of Fletcher) strata and walled in by the Browns Mountain formations. The Sugarloaf hills near Malignant cove, and Antigonish town, are rounded knobs upheld by cores of intrusive rock.

A very perfect drainage system has been developed in the Arisaig-Antigonish region, and lakes and swamps are, in general, absent. The upper portions of the stream channels cut into the metamorphic rocks, are youthful, V shaped gorges, with many rapids and falls. On the younger formations, drainage maturity is exhibited in well-graded channels, and, in some cases, meanders. However, in general, a recent downcutting has occurred through gravel previously deposited to a thickness of 6 feet or more above the present stream beds. To the northward, brooks from 3 to 4 miles long empty into Northumberland strait. To the south and east brooks attain the dimensions of rivers, and ultimately discharge into George bay.

General Geology.

TABLE OF FORMATIONS.

In the following table, new formational names proposed by various geologists, or by the writer, have been used in a number of instances, instead of the older terms of Hugh Fletcher. The work of the past season, as far as it concerns stratigraphy and the larger questions of geological structure, has served to confirm the views of Fletcher, but since the formational names used by Fletcher, in certain cases at least, implied the acceptance of views concerning correlation and general geological conditions that in all cases are not accepted by the writer, it seemed best to adopt a new scheme of nomenclature.

In the table of formations the older usage of Mr. Fletcher is indicated. The names applied to the three divisions of the Carboniferous present in the district are new terms proposed by the writer. In the case of the Devonian families, the name Knoydart, proposed by H. M. Ami,[1] has been adopted. The nomenclature of the

[1] Ami, H. M., Can. Rec. Soc., Vol. VIII, pp. 206-305 (1901).

Silurian is based on the classification put forward by Ami,[1] and W. H. Twenhofel.[2] The division of the upper Cambrian, and, possibly, Ordovician systems, are those originally proposed by Fletcher.[3]

SEDIMENTARY.

Cenozoic.

Quaternary—
1. Recent—Stream gravels and residual soils, modified glacial gravels.
2. Pleistocene or Glacial—Unstratified clay-gravel deposits.

Palæozoic.

Middle Carboniferous—
Listmore formation (Millstone Grit of Fletcher); light grey and red-brown sandstones, thin argillaceous shale, thin green conglomerate, etc.

Lower Carboniferous or Mississippian. Windsor group—
Ardness (Limestone division of Fletcher); brown and green sandy shale, flaggy sandstones, red and grey shales, (gypsum at Brierly brook), and compact grey limestones.

McAras brook (Carboniferous conglomerate of Fletcher) limy grey shale, green shale, breccia, and basal conglomerate, cut near base by amygdaloidal trap sheets.

Devonian (Lower) System—
Knoydart formation (upper Devonian of Fletcher); hard fine-grained, red, sandy shale, and hard, grey sandstone, cut by small diabase dykes.

Silurian System—
Arisaig group (Silurian of Fletcher)—
1. Stone House formation (=more or less of Ludlow of England) red shale and limestones, argillaceous limestone, and shales.
2. Moydart formation (approximates the Louisville of United States, or Wenlock of England); the red stratum or red shale, argillaceous limestone and shale.
3. McAdam formation (Rochester of United States or upper Llandovery of England); black shales and argillacous limestone; obscure basic intrusive.
4. Ross Brook formation (=Clinton of United States, or lower Llandovery of England); green shale with thin sandstones, dark papery slates, etc.
5. Beechhill Cove formation (=lower Clinton); sandstones, limestones, and shales. Rhyolite and volcanic breccia at base.

Upper Cambrian and possibly Ordovician Systems—
Browns Mountain group (Cambro-Silurian of Fletcher), including granite, greenstone, syenite or diorite stocks, and diabase and felsitic dykes—
1. Bears Brook formation; red and grey sandstone, grit and conglomerate.
2. Baxters Brook formation; red and green slates.
3. James River formation (upper Cambrian or Ozarkic); flinty slates and quartzites.

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[1] Ami, H.M.., op. cit.
[2] Twenhofel, W. H., op. cit.
[3] Fletcher, Hugh, op. cit.

IGNEOUS ROCKS.

Post-McAras brook	Amygdaloidal trap sheets.
Post-Knoydart	Diabase dykes.
Post-McAdam	Altered, obscure basic intrusives.
Pre-Ross brook	Dark red sheared dyke, amygdaloidal trap, rhyolite, and volcanic breccia.
Post-Baxters brook, but Pre-Great fault.	Greenstone intrusives of Malignant cove, Sugarloaf area, with associated granite porphyry and felsite, basic dykes, etc.
Post-James river (upper Cambrian), but Pre-Aras brook.	Syenite or diorite rocks east of Malignant cove. Diabase dykes, James River granite; diabase stock of Antigonish Sugarloaf.

DESCRIPTION OF FORMATIONS.

Browns Mountain Group[1] *(Cambro-Silurian of Fletcher).*

The Browns Mountain rocks (Cambro-Silurian of Fletcher) form the heart of the plateau area and are the oldest rocks of the Arisaig-Antigonish district. Extending from Cape George as a narrow belt along the shore, at the east boundary of this district they widen out so as to occupy nearly all the area south of the Hollow. Their course after leaving the district is westward and southward. From near the southeast corner of the area an outlier of Browns Mountain rocks extends northeast to George bay. Residual soil covers most of the plateau, and outcrops are best studied in the brook valleys.

Four igneous stocks occur in the area occupied by the Browns Mountain group—one of granite north of James River station; a small one of diabase (field determination) in the Antigonish Sugarloaf; one of trap or greenstone in the Malignant Cove Sugarloaf; and one of syenite (?) east of Malignant cove. Diabase dykes cut the James River granite, as well as the slates and quartzites. Similar dykes are of common occurrence in the vicinity of the Antigonish Sugarloaf and are of frequent occurrence throughout the metamorphic area. Granite porphyry, felsite, and basic dykes extend south and southwest from Malignant Cove Sugarloaf area.

The rocks of the Browns Mountain group are largely metamorphosed, and have been divided by Mr. Fletcher into three formations, all of which occur in the Arisaig-Antigonish district. The lowest, or James River formation, underlies all the area of the Browns Mountain group of the district to within a radius of less than 3 miles south of Malignant cove. Quartzite, varying from massive to thin-bedded, alternates with flinty slates. In colour the quartzite is in general bottle-green; its grain is fair sized, including scattered pieces of red jasper. The slates are commonly finely banded parallel to the stratification, in general are of an olive grey colour, and in many cases are harder than steel. In places the slates are crumpled, while the quartzites, when massive, often possess one or more sets of highly inclined joint planes.

The Baxter Brook formation succeeds the James River beds to the north, extending well into the intrusive area of Malignant cove. To it belong twisted and gnarled soft red slates, giving place occasionally to creamy slates, the colour of which appears to be caused by leaching.

The Bears Brook formation outcrops about Malignant cove, and in the valley of McNeills brook. In the latter place interbedded grey-banded slates, red slates, and brown grit are succeeded across a fault plane by fine-grained sandstone. Near Malignant Cove pond, a conglomerate consisting of pebbles of rhyolite, quartz, etc., lies upon the cleavage surface of a grey slate, and includes slate fragments. Nearby a coarser conglomerate, made up of rhyolite pebbles showing almost no sorting, overlies the finer grained conglomerate with an irregular, unconformable contact. Up Malignant brook conglomerate is succeeded by silicified purple grit.

The Browns Mountain rocks have suffered much folding, and the structure is further complicated as the result of disturbances due to igneous intrusions. Owing

[1] This name is adopted because of the widespread occcurrence of these rocks over the plateau of which Browns mountain forms an important part.

to their metamorphic condition, and the scarcity of outcrops, their geologic structure has not been completely worked out. However, it may be stated that in general the axes of folding extend northeast and southwest, parallel to the great features of the region. The younger formations belonging to the Arisaig and Windsor groups lie either unconformably against the foot of the Browns Mountain plateau erosion scarps, or else they floor the valleys that have been eroded through the Browns Mountain rocks. Examples of the latter relation are seen in connexion with the McAras Brook (Carboniferous conglomerate) formation northwest of the town of Antigonish, and also in the case of the lower formation of the Arisaig group, which occupies the valley followed by the railway west from James river.

Brachiopods obtained from the iron ore of Doctor brook and from quartzose schist near the east branch of Doctor brook have been identified by Professor Charles Schuchert as *Obolus (Lingulobolus) spissa* and *Lingulella* (?), the former of which occurs at Belle isle, in Conception bay, Newfoundland. The James River formation, in which these fossils occur, is, therefore, regarded as belonging to upper Cambrian (Ozarkic) time.

Basic dykes occur widely distributed throughout the formation, are usually vertical, and mainly trend with the formation axes. They are generally under 10 feet in thickness, and from field determinations are regarded as diabase. The granite stock of James river covers an area of about 2 square miles. The rock composing it is of a fine pink colour, and is rather low in quartz. Where observed the contacts are nearly vertical. In the southern extension of this stock, diabase dykes cut the granite along joint planes. Small outcrops of a syenitic character appear to the southwest, and a few small aplite dykes cut the country rocks. The Sugarloaf hill, north of the town of Antigonish, is supported by a small stock of diabase (?). North of this point numerous small diabase dykes occur.

The greenstone stock of the Sugarloaf of Malignant cove has been forced through the red slate, which still adheres to its highly inclined sides. Northwestward the intrusives continue as much-weathered greenstone rock, seen in the many small knobs that have been pushed through, and broken the slate cover. To the southwest gradations occur between the greenstone and a granite porphyry, the ground-mass changing from purplish green to grey. Phenocrysts of pink feldspar, up to three-fourths of an inch in length, are scattered through it, while quartz is recognized in irregular patches. Over an area extending about 4 miles to the south and southwest, a light creamy felsite is intruded indifferently along or across the bedding of the slates. Its frequent occurrence in connexion with the granite porphyry suggests that it may be a phase of the general intrusion of the Sugarloaf area. Similar felsite occurs near Browns Mountain settlement. The syenite (?) stock, east of Malignant cove, a good section of which is to be seen along the seashore, consists of much weathered rock, composed of pink to white feldspar and hornblende. Dark irregular dykes penetrate it.

Arisaig Group (Silurian of Fletcher).—The Arisaig group (Silurian of Fletcher) lies northwest of the fault scarp at the Hollow, and extends from Malignant cove southwest for about 6 miles along the shore, and is then overlain by the Knoydart formation, which takes on a dip, reversed in direction to that of the Arisaig, as may be seen near the contact in McAdam brook. A fine section of this group is exposed along the shore, while the brooks of the area furnish additional exposures.

Arisaig has been chosen as the group name because of its frequent association in literature with Silurian section, and because in Arisaig brook a good section across the upper four formations of the group may be seen. Ross brook has been substituted for Arisaig as applied by Ami and Twenhofel to the second lowest formation. Ross brook flows over obscured strata of this formation, and empties near the outcrops of the lower horizon of the formation as exposed along the shore. Honeyman and Fletcher divided this group into five divisions. In 1901, Ami proposed formation

names for the upper four divisions, but did not definitely fix the boundaries. These were fixed by Twenhofel[1] in 1909, and differ somewhat from the divisions as given by Fletcher. The writer has introduced the name Beechhill Cove formation, applying it to the lowest unnamed member of the Arisaig group.

The arenaceous character of the beds, and the cross-bedded sandstones seen in many places, together with ripple marks, which occur most frequently towards the top of the section, indicate near-shore conditions of deposition. As recognized by previous writers, these formations lie in a syncline, probably formed by flexure and fracture during down-faulting. The trough pitches southwest, and the formations occur in ascending order from rim to centre. Twenhofel has fixed the age of the group as embracing the time from the Clinton into the Ludlow, as is indicated in the table of a previous page, in which the lithologic characters of the various divisions are given.

The eruptive pink and greenish rocks at the base of this group were identified by Twenhofel, by means of microscopic examination and chemical analyses, as rhyolite and volcanic breccia. His slides have been examined by the writer, who quite agrees with his conclusion.

The contacts of these extrusives with the Beechhill Cove formation are apparently conformable with the bedding. In Doctor brook the strata are turned on end, the igneous rocks are brecciated, and have jointing or sheeting parallel to the contact. The sedimentaries are micaceous and schistose for some distance, and have taken on a sheeting parallel to the contact. On the shore east of Arisaig point the waves have lately exposed a contact, in which the thin sandstone beds warp around projecting rhyolite, and are compressed. The disturbance dies out within a few feet. Small dykes cut the sedimentaries for 40 or 50 yards from the contact. These dykes are light-coloured, with red blotches, and are stony to glassy in texture. A fine sheeting is assumed by the rhyolite next the contact, while the sedimentaries share the rhyolite jointing for a short distance. The contact dips at a high angle. The old character of the rhyolite, its breccia phase, and its generally conformable contacts with the sedimentaries favour the theory that the sedimentaries are the younger. However, the dynamic metamorphic conditions of the contacts—jointing, sheeting, dykes, etc., and the one instance of flexed beds—would support the theory that the rhyolite was intruded at the base of the formation as now known. Along the whole length of the rhyolite amygdaloidal trap occurs, cutting into it from the seaward side. Along the contact or cutting of the older igneous rocks there occurs a dark red dyke. It is much decomposed, and has assumed a fissile, friable character. What appears to be a part of the dyke assumes a nodular or pseudo-conglomerate character near Frenchman barn. In the McAdam formation, one, much altered, basic stock of small dimensions, occurs.

The Knoydart[1] *Formation* (upper Devonian of Fletcher).—The Knoydart formation extends southwestward from the Arisaig (Silurian of Fletcher) contact for more than 7 miles, measured along the fault line, and is overlain on the northwest by the Windsor group (Carboniferous limestone and conglomerate of Fletcher). The contacts with the Windsor group are frequently confused by minor faulting, but are unconformable, although a close approximation to parallelism in dip and strike is assumed, especially with the Ardness (Carboniferous limestone of Fletcher.) At the southwest the Knoydart overlies the Beechhill Cove formation of the Arisaig group, thus proving the unconformable contact with that group.

The red sandy slates and hard grey sandstones of this formation, as mentioned above, are unconformably related to all the other formations. The great fault separates them from the Browns Mountain group; unconformity, as shown by reversed dips across the contact in McAdam brook, separates them from the upper member of the Arisaig (Silurian) group, while at the southwest extremity they overlie the lower

[1] Am. Jour. Sci., Vol. XXVIII, August, 1909.
[1] Cf. Ami. op. cit.

member of the same group. As seen in McAras brook the lowest member of the Windsor (Carboniferous) group overlies them unconformably, while the same relations exist with the second member in Mill brook and farther west.

In the grey sandstones of the Knoydart formation Ami[1] found *Pterygotus, Pteraspis,* and *Cephalaspis.* These were identified by A. Smith Woodward and Dr. Henry Woodward, of the British Museum, who correlated the formation with the Hereford beds of the lower Devonian (Old Red sandstone). *Pterygotus* implies marine conditions, while *Pteraspis* and *Cephalaspis* imply brackish to freshwater environment. We may conclude then that these deposits were probably estuarine. That the final conditions were those of sub-aerial sedimentation seems probable from the sandy red slates seen higher up in the formation.

A few small diabase dykes cut this formation. The strata dip southwards at varying angles, but great flexures are lacking.

WINDSOR GROUP.

The Windsor strata extend in ascending order from McAras brook westward, transgressing older formations.

Extending from the east the McAras Brook (Carboniferous conglomerate of Fletcher) formation laps against the foot of the erosion scarp along the eastern edge of the plateau of metamorphic Browns Mountain rocks. The formation then continues southward between this plateau and its outlier, and swings away to the southwest as a narrow outcrop along the foot of the plateau erosion scarp. Immediately overlying the McAras Brook formation the Ardness formation (Carboniferous limestone of Fletcher) extends southward from near the southeast edge of the sheet. A short distance above the limestone the gypsum beds occur. Outcrops are then masked by soils and glacial gravels. Throughout the Windsor group outcrops are scarce, owing to the heavy mantle of gravels and soil. The shore and brooks alone give sections, and those of the latter are usually much interrupted.

The *McAras Brook Formation* (Carboniferous conglomerate of Fletcher) lies upon steeply eroded surfaces of the older formations. Fragments of these formations are common in the basal members, and in general, at the contacts, the underlying James River rocks are deeply stained with red. The red conglomerate is succeeded by soft, red and grey shales, with which the oil-shales occur.

The *Ardness Formation* (Carboniferous limestone of Fletcher) overlies the McAras Brook rocks conformably, wherever contacts have been examined. Thick-bedded, compact limestone, 20 feet or more in thickness, is succeeded by red and grey sandy shale, flaggy cross-bedded or nodular sandstone, etc. Along the south side of the area, a few hundred feet above the limestone, the gypsum beds appear. Their thickness and extent are masked by weathering, and stream erosion.

Brachiopods taken from the limestone west of McAras brook were identified by Professor Schuchert as *Beecheria Davidsoni,* Hall and Clarke, *(Terebratula sacculus.* Davidson), one of the characteristic and common species at Windsor. *Rhynchonella,* species undetermined, is rare, while *Productus* cf. *fasciculatus,* McChesney, is very common. *Productus cora,* as identified by Davidson, is also present, but it is not the true *cora* of upper Carboniferous time. Nearly all of these forms occur in the dolomite, at Windsor, in close association with this well known gypsum horizon of Nova Scotia. The evidence is, therefore, decidedly in favour of correlating the Ardness formation directly with the limestone and gypsum outcropping at Windsor.

With the one exception of the limestone beds, the characters of the Windsor group sediments indicate sub-aerial or shallow water origin. The uniformly oxidized condition of the conglomerate and shales, as shown by their red colour and lack of organic remains, apparently indicates either exposures to the atmosphere, and a periodic lower-

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[1] Geol. Soc. Am. Bull. Vol. 12, pp. 301-312. 1901.

ing of the ground-water level during sedimentation, or such a poverty of shallow water marine life as to be incapable of deoxidizing the the sediment when it finally reached the sea. The entire absence of marine fossils in the red beds favours the sub-aerial interpretation. The white and grey sandstones, in places cross-bedded and elsewhere containing plant remains, indicate that they were deposited in shallow water near the habitat of the plants.

The limestone beds furnish evidence of marine conditions during their formation, while the gypsum horizons record the existence of isolated, shallow water pans.

The *Listmore Formation*[1] (Millstone Grit of Fletcher), occurring in a limited area along the shore, at the west edge of the sheet, consists of soft, friable reddish-brown sandstone, with thin argillaceous shale beds containing poor fossil plants. Ripple marks and cross-bedding are occasionally seen. Towards the top, the harder white sandstones are more common. In the area studied there is no apparent break in sedimentation between this formation and the Windsor group, and the same evidences of sub-aerial origin are seen as were noted in the case of the Ardness sandstones.

The Windsor formations have suffered only a slight amount of flexing. Some minor faulting has occurred, as is best seen in the three limestone beds described by Fletcher west of McAras brook, which are now known to be one and the same bed successively faulted to the northeast parallel to the shore. The dragged portions, and fault planes, are clearly exposed. The amygdaloidal trap sheets intruded between the beds of the McAras Brook conglomerate have probably been duplicated by faulting. The Listmore formation is practically undisturbed, and dips gently to the northwest.

Pleistocene Formations.—Overlying the younger formations are considerable deposits of glacial gravels. Erosion has modified these, and many isolated, rounded hills have thus been formed. The commonest pebbles are from the James River slates and quartzites, which occasionally show glacial scratches. The matrix is often of a clayey character, and a red, marly clay is frequently observed at the base of the deposits. The upper portions of the gravels are usually well sorted and bedded.

Glacial striæ were recorded in a number of cases. An average direction of the characteristic striæ is about S 10° E magnetic bearing, or S 34° E true bearing. The movement is assumed to have been southerly, but no critical evidence as to this is at hand.

Elevated Beaches and Stream Gravels.—Three elevated sea beaches occur along the shore east of McAdam brook in connexion with the modified glacial gravels, the upper surface of which, at many points, is assorted and bedded, with a gentle dip to the southwest. The highest of the three is about 120 feet above the present sea-level. The angular nature of the old sea-cliffs, and the undisturbed arrangement of their sea-washed gravels, indicate that the sea beaches are post-glacial. As already mentioned, about 6 feet of recent gravels occur along the graded portions of the streams, sometimes preserving on their surface one or more sets of meander cusps. Through these the streams are now cutting.

Historical Geology.

The geological history of the Arisaig district, as seen in surface exposures, begins in upper Cambrian time with the deposition of the Browns Mountain quartzites, slates, and conglomerates. These are the deposits of a shallow transgressing sea, which was followed by a long emergent period, with folding, intrusion, faulting, and erosion. Should the rhyolite pebbles of the Bear Brook conglomerate be correlated with the rhyolite of the Frenchman barn and Arisaig point, the extrusion of the latter rhyolite must have occurred before Bear Brook time. Later came the Arisaig (Silu-

[1] By Ells this formation is placed in the middle Carboniferous. G.S.C. Report 1885-E 7-33.

rian) formations, deposits of an invading sea, probably over the old rhyolite flows. It was a comparatively shallow water sea, as is shown by the arenaceous character of the sediments, cross-bedded sandstones, and the many ripple-marked zones in the shales. An emergent erosion interval followed.

Upon the bevelled formations of the Arisaig group the Knoydart (upper Devonian of Fletcher) formation was deposited in lower Devonian time, under estuarine conditions, as is shown by its mixed marine and freshwater fauna.

That the great fault along the Hollow preceded the Listmore deposition is indicated by the undisturbed condition of the Listmore formation (Millstone Grit of Fletcher) to the west of this district, as shown on Fletcher's map.

Beginning with the McAras Brook conglomerate, a shallow sea again invaded the area, washing the base of the emergent metamorphic rocks and transgressing the Knoydart formations (Devonian of Fletcher). Deeper water conditions followed, with a limestone making period. This is recorded in the Ardness (Carboniferous Limestone of Fletcher) formation with its Windsor brachiopods. Then followed emergence, and in the south of the area shallow water pans were formed, in which the gypsum beds were deposited due to excessive evaporation. Deposits of sandstone, probably subærial, continued to the base of the Listmore (Millstone Grit of Fletcher) formation, and then, after an erosion interval observed outside of the area under consideration, sub-ærial sedimentation again proceeded, and the Listmore sandstones were deposited. The wood and plant remains of this formation indicate freshwater conditions, and a somewhat luxuriant flora.

With the advent of freshwater sedimentation, an emergence began, which probably was a part of the closing Palæozoic uplift known as the Appalachian Revolution. From this time until the glacial period the records of the area are those of erosion.

Following the Appalachian Revolution the evidence does not go back of a period of peneplanation, with its implication of a long preceding erosion cycle. Whatever formations overlay the higher portions of the Browns Mountain (Cambro-Silurian of Fletcher) group and Knoydart (upper Devonian of Fletcher) formations were prebevelled across and reduced to a plain of low relief. That the Arisaig (Silurian of Fletcher) group and Knoydart (Upper Devonian of Fletcher) formation were previously down-faulted, and suffered the general peneplanation in approximately their present relation to the Browns Mountain group, is shown by the sub-equality in the elevation of their hilltops to the general peneplain level.

The effects of subsequent erosion on the metamorphic plateau, and along the contact scarps which bound it, are comparatively insignificant. Other data as to the age of peneplanation have not been obtained from the area.

After peneplanation, elevation took place, and before glacial time the younger formations were deeply eroded. This conclusion is based on the evidence of glacial striæ observed on Arisaig rocks about 500 feet below the average elevation of the plateau nearby, and recording a degree of differential erosion which seems far too large to assign to glacial action alone. Subsequently the glaciers scored and gently modified the plateau, sweeping away a large part of its surface debris and depositing it to the thickness of tens of feet over the low lying formations.

After the retreat of the ice, or during the retreat, elevation of the strand line of more than 120 feet occurred, as is shown by the sea beaches. This took place by at least three main stages, corresponding with the number of beaches. That water at least re-sorted the gravels higher than this is proved by bedded gravels at James river, more than 180 feet above sea-level. In recent times thin deposits of stream gravels have been laid down, and now another uplift is taking place, causing the streams to cut down.

Economic Geology.

Copper.—Copper stains have been observed, as recorded by Fletcher, in a number of localities. They are always connected with the Windsor (Carboniferous lime-

stone and conglomerate of Fletcher) group, and generally are merely a green stain in sandstone connected with plant remains. Near Brierly brook two shafts have been sunk and a tunnel driven in the McAras Brook conglomerate. The shafts are said to be about 30 feet deep and the tunnel about 60 feet long. Copper ore is said to have been obtained from the eastern shaft, but from the material of the dump and the surrounding rock no workable deposits are to be expected.

Iron.—The interbedded, fossiliferous earthy hematite deposits of the Moydart formation (Niagara of Fletcher) have been opened up on Arisaig and Ross brooks, nearly one-half mile apart. That two outcrops occur in the latter brook may be due to faulting, for a disturbance in the strata is evident. The character of the ore is clearly that of a sedimentary deposit. Two feet three inches is an average thickness of the bed.

The James River formation has iron ore (hematite) deposits scattered widely through it. Northeast from Browns Mountain P.O. two showings of coarse grit, impregnated with hematite, have been prospected by Mr. Alex. J. McDonald. They are about one-half mile apart, and may or may not be related. Ore zones of from 5 to 20 feet have been uncovered, and assays are said to run from 22 to 30 per cent iron. Much quartz grit is seen in the ore, which grades into the country rock. The latter is usually of finer grain than in the ore zone. In the Iron Brook area isolated prospects have been opened up, but most of the ore is in the belt of three parallel leads, traced by Mr. George E. Corbitt for more than 2 miles, Older work has exposed ore, probably of the same zone, for nearly a mile farther east. The ore is a fine oolitic hematite, and grades rather abruptly into the quartzite of the James River formation. Passing northeastward, the leads are successively offset to the south by a series of faults of small throw, and ore of varying thickness is thus brought into proximity. Thicknesses of 8 feet and more have been exposed, but the average of the leads is much less. For assays, maps, etc., see J. E. Woodman's report of 1909, mentioned above.

The hypothesis of sedimentary origin is upheld by the continuity of the ore along the strike of the strata; its oolitic character; the fossils obtained correlating these deposits with the sedimentary deposits of Great Belle isle; and their pre-intrusive and pre-fault origin. The variations in thickness oppose the above hypothesis, but may find explanation in uneven shallow water deposition, and later faulting. From the above considerations the writer concludes that the ores belong to the sedimentary bedded deposits.

As the faults and dykes of the ore area tend to be vertical, less disturbance is to be expected with depth than with horizontal dimensions, but the indications are that the ore thickness is variable.

At the western end of the explored leads Mr. Corbitt had driven a tunnel more than 70 feet, to cross the ore zone, but had not reached ore when last information was obtained. The general development consists of cross-trenching and stripping.

Oil-shale.—Little information is to be had in this area as to oil-shale. Pits expose a good appearing, shiny, black shale in the neighbourhood of Maryvale, and the flat structure of the formation would indicate wide extent.

Gypsum.—The thick deposits of gypsum along the south border of the district are visible to all who travel on the Intercolonial railway. That they are extensive, and of good quality, is evident, and development only awaits a sufficient demand for the raw material.

Limestone.—A good quality of limestone for burning purposes is obtainable near Brierly brook, near Antigonish town, and in many places along the limestone horizon.

GOLDBEARING SERIES OF LAHAVE BASIN, LUNENBURG COUNTY, NOVA SCOTIA.

E. Rodolphe Faribault.

INTRODUCTION.

The field work of the past season, 1910, was directed to a continuation of the geological and topographical mapping of the goldbearing series of Nova Scotia. The area surveyed during the year covers the upper part of the basin of Lahave river. It extends northward from Bridgewater up to the old Dalhousie road, and comprises the northwestern part of Lunenburg county and small portions of Annapolis and Kings counties. This completes the surveys and other field work necessary to finish the Springfield sheet, No. 86, and the eastern part of the New Germany sheet. No. 85, of the series of the Nova Scotia map sheets.

My assistants were Messrs. J. McG. Cruickshank, and W. J. Wright, for the whole season, and D. S. McIntosh and M. H. McLeod for a part of the season. Field work was commenced on June 4 and continued up to the end of October

Leaving my party at work in the field in the middle of July, I was engaged for a little over two months in the Chibougamau mining region, Quebec, as one of the commissioners appointed by the Quebec Government to report on the geology and mineral resources of that region; my services having been loaned by the 'Survey', to the Quebec Government. for this purpose. I again joined my party in Nova Scotia at the end of September, and continued field work until the end of the season.

Three visits were paid, in June, October, and December, to the tungsten deposit at Scheelite, near Moose River Gold Mines, Halifax county, already reported on at some length. in the Summary Reports of the last two years. These examinations were made for the purpose of assisting the Scheelite Mines Company in planning the development work then in progress, preparatory to immediate exploitation. At the last visit the survey of the mine was brought up to date, in order to perfect details of the structure of the veins, and to locate the mine workings on the plan started last year. A copy of this plan was furnished the Company for their information. The additional information gained this year confirms the conclusions published in last year's Summary Report regarding the probable structure of the veins and ore-shoots, the existence of an important fault, and the best method of development to follow for exploitation.

CHARACTER OF THE DISTRICT.

The district surveyed presents the appearance of an undulating plain gradually rising from the sea northward. until at a distance of from 30 to 40 miles it attains elevations of 700 to 800 feet along South mountain, which forms the height of land between the Atlantic and the Bay of Fundy. Everywhere, may be seen the evidence of the action of vigorous erosion, which has resulted in the formation of hills and depressions which have a general southerly trend, bearing a little eastward towards the sea. The district is largely drained by the main Lahave river, which flows in a narrow valley on an almost straight course to the sea. The waterway is a succession of small lakes, stillwaters, rapids. and falls, and has a total descent of over 500 feet in the 27 miles between the old Dalhousie road and the head of tide at Bridgewater. The principal tributaries are. from the east, the North Branch and North river; and from the west, the West Branch. and West or Ohio river. The North Branch drains

Sherbrooke or Ninemile lake, which is 7¼ miles in length, and lies 454 feet above mean sea-level. These streams afford several important water-powers, a few of which are being partly utilized. The district is also intersected by numerous small streams, lakes, and stillwaters.

The intervals betweeen the hills are in many cases occupied by swamps and marshes, and in some instances by peat-bogs; or they form rocky barrens which afford good rock exposures; or are strewn with granite boulders and debris derived from the north. Many of the hills are of glacial debris, and seldom rise more than from 100 to 200 feet above the general level of the country. Most of these hills are well-defined, oblong, dome-shaped drumlins or long, lateral moraines of boulder-clay and till, having a general north and south trend. Terminal moraines largely made up of granite debris, and running east and west, are also represented, as in the case of the hill to the south of Menamkeak lake.

Part of the upland affords good soil for agricultural purposes, and where it is not already settled is covered with hardwood forest. The greater part of the back country is well wooded with a fine growth of spruce, pine, and hemlock, as well as hardwood; and extensive lumbering operations are carried on, principally by the Davison Lumbering Company, to the north of the old Dalhousie road. This Company operates 33 miles of railway, over which the logs are hauled to their saw-mill at Springfield; whence the lumber is carried over the Halifax and Southwestern railway to Bridgewater, for shipment by sea. A pulp-mill is also in operation at New Germany.

The Middleton and the Caledonia branches of the Halifax and Southwestern railway run through the district, and give daily communication with Halifax and Yarmouth.

GEOLOGY.

The greater part of the district is underlain by the quartzites and slates of the Goldbearing series; but towards the north and northwest these rocks are cut by granites of Devonian age, which extend northward across South mountain to the Annapolis valley, and form part of the very large granite area which constitutes the backbone of the western counties of the Province. A small isolated mass of greenish grey granite was located far away from the main area, at a place situated 2 miles east of Italy Cross station, and one-fourth of a mile north of the outlet of Wallace lake. At this locality, a recent conglomerate has been prospected for gold.

In the absence of fossils and other conclusive evidence, it has been customary to provisionally refer the Goldbearing series to the lower Cambrian, though on account of their similarity to the quartzites and slates of the Avalon peninsula of Newfoundland, which have been assigned to the Pre-Cambrian, as well as for other reasons, it is possible that they may be Pre-Cambrian.

The series as exposed in different parts of the Province has been estimated to have a total thickness of over 5 miles. This great series of rocks falls naturally into two lithologically distinct conformable divisions: a lower one, called the Goldenville quartzite; and an upper one, called the Halifax slate.

The Goldenville division is mostly made up of thick beds of grey, altered quartzose-sandstone or quartzite, locally called "whin"; interstratified with beds of dark clay slates, which are quite numerous at certain horizons, but almost wanting at others, especially at the top of the division. At many places, and more especially near granite intrusions, these rocks are much altered, and have become schistose, with a development of very minute scales of mica along the planes of schistosity, which gives them a characteristic glistening appearance when split. The Goldenville division has a thickness of over 3 miles of strata in the eastern part of the Province.

The Halifax division is composed entirely of argillaceous slates, in some cases arenaceous, and with occasional flinty layers holding iron pyrites. Dark grey layers

occur sparingly, and are sometimes found to be slightly calcareous, especially when occurring at the base of the division. The lower beds are olive green in colour, and are followed by others of dark grey colour which gradually give way to a great thickness of glistening bluish-black, foliated, graphitic, soft clay slates, often pyritous, overlain by banded, black and grey arenaceous slates. The thickness of the Halifax division has been estimated at over 2 miles of strata.

After their deposition these sedimentaries were uplifted and folded into a succession of anticlines and synclines following northeast and southwest courses. They were then subjected to extensive erosion, which removed the upper part of the folds and gradually planed the surface down to its present attitude, exposing the edges of the uptilted, once deeply buried strata. The rocks, generally, dip at high angles, ranging from 45° to 90° from the horizontal.

In view of the intimate relation existing between the structure of the anticlinal folds and the occurrence of the gold-bearing quartz veins, special attention was paid to the location and structure of the anticlines and synclines. A section across the folds along Lahave river from Bridgewater to the old Dalhousie road gave a succession of five major anticlines and synclines in a distance of 25 miles. Minor folds were also observed along the crest of some anticlines, especially for the first 4 miles above Bridgewater, where the strata have been plicated into a succession of small folds or undulations. Going up Lahave river the five anticlines are met with in the following order from south to north:—

(1.) *Leipsigate Anticline* crosses the river at Bridgewater where it is composed of several minor folds in slate well exposed along the west side of the river. These folds converge westward as they approach the Leipsigate gold district, where they join and form a broad dome along which the Goldenville quartzites are brought to the surface and extend to the west. The most southerly of the minor anticlines extends eastward through the Blockhouse gold mines where the Goldenville quartzites are again brought to the surface on a smaller elliptical dome one mile long by a quarter of a mile wide. From these two domes situated, respectively, west and east of the river, the anticline pitches towards the river, forming a cross syncline which is strongly marked and extends north and south along the river, affecting the other folds similarly but to a less degree.

(2.) *Spondo Anticline* crosses the river 4½ miles north of the first anticline and half a mile south of Mossman station. It extends eastward to the granite, passing the south end of Big Mushamush lake and through the Spondo gold prospect, where a large saddle-shaped vein has been uncovered. Westward, it crosses Wile and Fire lakes south of Baker settlement. It shows nothing but slate along its whole course. A minor anticline between the above two anticlines was located in grey slate at Waterloo, where it crosses Frederick and Matt lakes, but it could not be traced eastward to Lahave river on account of the drift.

(3.) *Northfield Anticline* crosses the river at Northfield station 3 miles north of the second anticline. Traced eastward it crosses the north end of Big Mushamush lake and continues through Caribou lake where the slates are superseded by the quartzites which are brought up to the surface along a broad dome extending to the granite. West of the river the anticline passes near Clifford post-office where it converges with the adjoining north syncline in dark grey slate.

(4.) *Pleasant River Barrens Anticline* is situated 4½ miles north of the third anticline, and crosses the river at an island 2¼ miles north of Riversdale station, where the lower quartzites appear at the surface on a westerly plunge of the fold and spread out towards the east beyond Newburn and New Cornwall to the granite. It crosses the outlet of Indian lake and the north end of Church lake where numerous cross veins and a few interbedded veins have developed. West of the river the quartzites are overlain by the upper grey slates on the transverse syncline which is here strongly marked;

but, a short distance farther west, the quartzites again appear at the surface on a broad elliptical dome, on the eastern end of which the gold mining district of Pleasant River Barrens has been located.

(5.) *Cherryfield Anticline* occurs at a distance of 9½ miles north of the fourth anticline where it begins at the granite contact on the main river, directly east of Cherryfield station, and extending eastward, crosses the Sarty road at the school house and the Sam Moore road half a mile south of the bridge over North river, and ends at the granite, 3 miles farther east. This anticline brings to the surface lower beds than any other fold in the district, exposing at the surface a thickness of 2½ miles of the Goldenville quartzite, which extends southerly for 3½ miles to the Halifax slate, and northerly beyond the next syncline to the granite along the old Dalhousie road. The strata dip at angles increasing from 25° to 80° on the south side of the anticline, and from 25° to 65° on the north, and appear to form a very narrow dome near the Sarty school house, where quartz veins have been uncovered.

Some interesting granite contacts are well exposed at a few points along the boundary line, one of which may be observed at Dog falls on the west side of Lahave river, below the bridge, half a mile north of Cherryfield station. As a general rule the quartzites are altered quartz-mica schists, but the strata show no local disturbances as a result of the granite intrusion.

Evidence of dislocation and faulting has been observed, however, at many places, especially in the vicinity of large projections of the granite into the sedimentaries, but the disturbances are apparently the result of movements that took place subsequent to the irruption of the granite. At Upper New Cornwall—between Otter lake, the northeast end of Big Mushamush lake, and the south end of Church lake—the strata are much disturbed, and there is probably an important fault running northerly in the direction of Union Square, Morton Corner, and Sarty, along which the western block has moved south with reference to the east one. Towards the south, this fault probably runs along the eastern shore of Big Mushamush lake and passes through Slaughenwhite island and Farmville towards Blockhouse. Along this course much brecciated country rock and quartz is shown. The cross veins operated at Blockhouse are probably a zone of fractures on the southern extension of this fault.

Economic Geology.

GOLD.

Leipsigate Gold District.—Two gold mining districts, Leipsigate, and Pleasant River Barrens, are situated in the area surveyed. A detailed survey of Leipsigate was made in 1904 and a report on that district was included in the Summary Report for that year, pages 321-329, together with a plan on the scale of 500 feet to 1 inch, published separately. After 1904, operations were continued until 1908 on the Micmac fissure vein by the Mimac Gold Mining Company, and a depth of 596 feet has been attained. When in operation the Micmac mine proved a good producer, and there is every reason to believe that under good management it should still continue to yield well. In 1905 and 1906 some work was also done at the Owen mine on the same vein. A little prospecting was done in the northern part of the district by Simeon Erust and others, but no important discovery has been made since the survey of 1904.

Pleasant River Barrens Gold District.—The district is situated in Lunenburg county, on the Pleasant River road, 15 miles north of Bridgewater, between Rhyno and Shingle lakes, on the eastern end of a broad elliptical dome of quartzites, which is 4 miles long by 2 miles wide, and is surrounded and overlaid by the slates of the Halifax division. The auriferous quartz veins occur at the outer edge of the dome in slate layers interstratified between thick beds of quartzite (which often

stand out prominently and form a succession of parallel ridges with intervening swales) curving gradually around the eastern part of the dome and dipping towards the southeast, east, and northeast at angles of 20° to 40°. The district has been idle for the last twelve years, hence only a cursory examination could be made of the old workings. Several veins have been uncovered, a few of which have been developed, but none of them have been exploited, except to a limited extent. The more important veins are the Dunbrack, Mill, Pine Tree, Brignell, Ernst, and Bent leads. A specially rich but narrow pay-streak was worked for a short time on the Dunbrack lead at the intersection of an angular vein dipping north 60°. One fissure or cross vein, was also discovered by James Deal, crossing the strata in a southwesterly direction. Most of the work was done in the eighties and nineties, and three stamp-mills are reported to have been erected.

On the east side of the river, gold-bearing veins have been uncovered and prospected at several places, but the results obtained appear to have been unsatisfactory. The most important veins developed are the following:—

On the southeast side of North river, 2 miles east of Meisner post-office and three-fourths of a mile east of O. Acker's house, a vein was discovered in 1892 by Thomas Acker, and worked by a Windsor company to a depth of 40 feet; a five-stamp mill was built and 60 tons of ore crushed, but the prospect was finally abandoned. The vein is 1 to 10 inches thick, dips north 78°, and is interbedded in altered quartzite, in contact with the granite. In 1909 a few other parallel veins were prospected by David Lawrence.

At Upper New Cornwall, at Rocky point on the northeast shore of Big Mushamush lake, two veins were opened in or about 1888 by Freeman Millet, in slate between walls of quartzite. On the north vein there is a pit 21 feet deep, and on the south one, two pits 24 feet deep, but the whole prospect is now flooded by the lake.

Farther north, half a mile south of Indian lake, on the east side of the road, a vein 12 inches thick cutting across the quartzite was prospected by W. H. Prest with two shafts 25 feet deep, and some ore was crushed at the Blockhouse mill. Numerous other cross veins have been located between this prospect and the foot of Indian lake along the fault passing in this vicinity. Ore-shoots may possibly occur at the intersection of some of these cross-veins with the interbedded veins which are found along the Pleasant River Barrens anticline at the foot of Indian lake and the north end of Church lake.

COPPER.

Over twenty years ago, at Dalhousie East, Kings county, situated 10 miles northeast of Springfield station, on the west side of Crossburn road and three-fourths of a mile north of Old Dalhousie road, a shaft was sunk to a depth of 165 feet on a copper-bearing vein in granite. At the surface the vein appears to strike S 25° E magnetic, and dip vertically. Samples picked up at the mouth of the shaft show the ore to be chalcopyrite and chalcocite in a gangue mostly composed of granite and quartz. An analysis of the samples made at the Mines Branch gave 1·05 per cent of metallic copper, but did not show the presence of gold, silver, nickel, tin, or tungsten, for which elements they were tested. Irving Smith, who occupied the farm on which the shaft was sunk, and also worked at the mine, furnished the following information: The vein was discovered about the year 1876 by Ainslie Wilson, and the shaft was started in 1890 by a Bridgewater company. The shaft measures 14 by 8 feet, is 165 feet deep, and is timbered to a depth of 100 feet. At the cropping the vein was 12 inches wide, and proved rich to a depth of 20 feet, where large crystals of quartz were found, after which it decreased in size and value, and at the depth of 100 feet it began to dip towards the east, and its size became less than 2 inches. At a depth of about 20 feet, a drift was driven 12 feet one way and a few feet the other. The vein has not been traced at the surface, because its outcrop is probably of very limited

extent; as in the case of the King vein at Lake Ramsey, near New Ross. Drift of similar ore is reported, however, to have been found half a mile farther north in the direction of the vein, half way between Irving Smith's present house and Sixtymile lake, where also traces of copper were found on an outcrop of granite.

IRON OCHRE.

A deposit of yellow and red ochre was found at Auburndale, along Heckman brook, on the west side of Lahave river, and 4 miles north of Bridgewater. The deposit is said to be 1 to 2 feet thick, and 50 tons taken from John Penney's farm were shipepd to Halifax in 1908.

WHETSTONE.

A quarry of slaty rock suitable for the manufacture of whetstones was opened in 1901 by George McFaden of Bridgewater, at Parkdale, Lunenburg county, at the outlet of Whetstone lake, 9 miles northeast of New Germany. The rock is composed of beds of hard, greenish, grey, siliceous and argillaceous slate, occurring at the base of the Halifax slate division; the strata dips south at an angle of 75°. After about two years operation, McFaden sold the quarry to a Maine company, which continued operation for a short time, and erected a building for machinery, which, it is said, never reached the quarry on account of financial difficulty. The quarry is now 3 to 6 feet deep, 12 feet wide, and 25 feet long.

TIN AND MANGANESE AT NEW ROSS.

At New Ross, Lunenburg county, some distance east of the district surveyed last summer, two important veins, one bearing manganese and the other tin and copper, were opened last summer.

A vein of manganese recently discovered by Ernst Turner in granite, 2 miles to the north of Wallaback lake, and 8 miles north of New Ross, has been opened by a Windsor company, under Dr. H. W. Cain's management, with a shaft to a depth of 145 feet; and it is reported, with very satisfactory results. The vein varies in width from 4 to 18 inches and dips nearly vertically. The ore, which carries streaks of red hematite near the surface, is found to be exceptionally free from iron at a lower depth. An assay of some samples gave only 0·1 per cent of iron, with 5 to 6 per cent of carbonate of baryta. A similar vein of manganese, occurring at a distance of 1¼ miles to the south, was exploited a few years ago by Dr. Cain, but has not yet been reopened.

A tin-bearing vein, also recently discovered by Ernst Turner, at Mill Road, 4 miles north of New Ross, has been prospected under the management of A. L. McCallum. It has been proved to a depth of 20 feet, and for a length of 250 feet, while the float has been traced half a mile towards the north. The vein is 24 inches wide, mostly made up of quartz, merging with granite at the sides, and carries at the middle a streak of rich ore from 3 to 5 inches wide. Several assays of the ore made by Mr. McCallum have given from 10 to 30 per cent tin, and 8 per cent copper, present in the form of cassiterite and chalcopyrite, with association of tungsten-bearing and zinc minerals. Several other veins occurring in this vicinity, and showing copper, molybdenite, etc., have not yet been prospected.

TUNGSTEN.

A new discovery of tungsten ore, in the form of scheelite, has been made by W. H. Prest, at Middlefield, Queens county, near the Fifteenmile Brook gold mine, and prospecting was started last fall in order to trace the float to the parent vein.

WATER AND BORING RECORDS.

(*E. D. Ingall.*)

During the past year the work of collecting records of deep wells was continued substantially along the lines originally adopted: by correspondence, following information as to borings, obtained through newspaper or other channels. Whenever time permitted, letters were written; as personal correspondence was found best in the opening of negotiations for the desired co-operation of those in control of operations.

Having obtained promises of samples and information from drillers and operators, constant watchfulness is found necessary, as well as further correspondence, in order to ensure, in many cases, the acquisition of complete sets of samples, and other data. It is important to get notification of the cessation of boring operations, or even of their temporary suspension; as great confusion arises in attempting to keep in touch with boring operations over the whole of Canada, unless the drillers keep the Geological Survey officer in charge promptly posted. Ready-addressed, postage free notification cards, for reducing the work entailed upon the driller to a minimum, are always sent out, and it is hoped, as the value and needs of this work become better known, that the methods of co-operation may continue to improve.

Accompanying requests to drilling operators, for co-operation, as well as in response to requisitions received at the Geological Survey, bags, etc., for the return of drillings samples have been sent out.

In all work which must be done by correspondence, it has been invariably found, that but a small percentage of the circulars or letters sent out bring replies. Naturally, with people busily engaged in commercial enterprises, any effort entailed without prospect of immediate personal gain is apt to evoke only slight and intermittent response. Then too, professional men are apt to hesitate before giving for public use, information upon the exclusive possession of which their success largely depends. It is all the more gratifying, therefore, to have met with considerable response in the form of full sets of drillings and particulars, from a number of operators of important deep wells in various parts of the country.

Amongst these may be mentioned two deep wells which were drilled in the eastern Ontario Palæozoic basin—at Plantagenet, and Carlsbad Springs. Both these were bored in hopes of proving workable pools of gas or oil. The first named penetrated to the top of the Potsdam, and the other is yet in progress. The information regarding these two wells—together with that previously obtained of wells located near Ottawa, and at Chesterville, and Monklands—should give important results when the final and careful working out of the logs, lithologically and palæontologically can be accomplished. With this end in view, a number of short trips were made in the Ottawa district—in company with Dr. Percy Raymond—Invertebrate Palæontologist to the Survey—in order to acquire a better acquaintance with the detailed features of the geological column as shown at various points in the escarpments developed along the Ottawa River valley. A number of these sections, as measured by Dr. Raymond, have been prepared by him for publication.

The only other field work consisted of a trip to Farnham, Quebec, in connexion with two deep borings put down by the Militia Department, in search of water for the supply of their camp at that place. It was thought possible that some data might be found in the district throwing light upon the structural geology, and consequently upon the chances for a water supply, and that there might be some visible evidence of fracture effects in connexion with the Great Champlain fault, believed to pass a

few miles to the eastward. It was found, however, that the covering of drift practically masked all such, hence the drilling had to be located without them, and, unfortunately, the experiment was without practical result.

A like experiment to the foregoing was prosecuted by the Militia Department, at Longueuil Barracks, near Montreal; but although interesting geological data were obtained, this well also proved unsatisfactory from an economic standpoint.

Through the efforts of Mr. J. A. Dresser, of the Survey, a partial log was obtained from the boring at St. Barnabé, near St. Hyacinthe, in the Eastern Townships of Quebec. This hole is of especial interest, having proved the existence of a pool of natural gas under a fair pressure. Particulars of the results of a hurried examination of this district will be found in Mr. Dresser's preliminary report on page 218.

The technical problems which arose in connexion with the above-mentioned wells entailed considerable research into the geological literature relating to the region, the structural features and varying thicknesses, and lithological characters of the formations. The need of further data, whether gained through borings or by a continuation of the field research already made, is constantly brought to mind in this connexion.

Owing to the liberality of Dr. Henderson of the Maritime Oilfields Co., there has been added to our official records, a very full set of logs of the 15 wells bored by that Company near Moncton, New Brunswick, the locations of the holes being also marked on a map. Sets of samples of drillings from these holes have also been donated. Later, when opportunity presents itself to thoroughly work out the data available in this group, results of importance to a further understanding of the intricate geology of this district should accrue.

The public interest in borings for gas and oil in the northwestern provinces has been very prominent of late years, and sets of drillings have been acquired from a number of points scattered over that extended region.

A function of the Water and Borings Division that is receiving growing recognition is that of preparing technical memoranda in answer to the inquiries of operators regarding geological conditions and economic possibilities for gas, oil, or water, in various parts of the country where boring work is contemplated. The needs of the various and quite numerous inquirers have been met, as far as possible; the necessary investigation of the very extensive technical literature, on their behalf, occupying a very considerable portion of the time available for the routine work of the branch.

Considering the time and funds available for the collection and interpretation of boring data, and for rendering assistance and advice in furtherance of this branch of the country's exploratory activities, the results attained are quite encouraging, and give hope of an extension of usefulness in the future, as the operators are reached, and a wider appreciation established amongst them of the need and value of the work

SECTION OF MINERALOGY.

(Robt. A. A. Johnston.)

The work performed in this section has been of the same general character as that of previous years. Nearly 600 specimens have been received, examined, and reported upon, and in addition, detailed examinations have been made of a number of interesting minerals, the results of which are given hereunder.

HEXAHYDRITE, A NEW MINERAL.

The material which forms the subject of the following note was forwarded to the Geological Survey by Mr. F. Sones, Gold Commissioner at Clinton, British Columbia, with the information that it had been found on the east coast of Bonaparte river, about half-way between Cargill and Scottie creeks, in the district of Lillooet, British Columbia. The sample was made up of two specimens, one of which, measuring 4 inches in length by 2 inches in thickness, consisted of the mineral about to be described along with some scattered remnants of decomposed rock matter; the other specimen, a much larger one, consisted for the most part of decomposed rock matter of a character like that just mentioned. It has a schistose structure, but it has so far decayed that its original composition is completely obscured and little more than a residue of silica remains. It is not at all unlikely, however, that the original of this rock has furnished the basic constituent of the associated mineral.

The mineral occurs in the form of seams and scattered patches in the altered rock matter just described. Some of these seams attain a thickness of nearly half an inch. In general they present a moderately coarse columnar structure; occasionally, however, the mineral is seen to assume a delicately fibrous form. In the material at hand no distinct crystals have been observed, and the cleavage, although clearly prismatic, is not very well defined. The mineral is readily friable, and breaks with a fine, subconchoidal fracture. It has a pearly lustre, and its colour is white, modified by a delicate green tint; it is opaque even on very thin edges, and has a bitter, saline taste.

Before the blowpipe, on charcoal, the mineral swells and emits bubbles of vapour, but does not melt, and ultimately leaves an infusible mass, which has no effect on moistened turmeric paper. When moistened with a solution of cobalt nitrate and reignited the mass becomes pink. In the closed tube it yields a large amount of water which reacts neutral to test papers. It dissolves readily in cold water, yielding a clear solution; after addition of ammonium chloride this solution does not give a precipitate with either ammonia or ammonia carbonate, but when a solution of sodium phosphate is added to the ammoniacal solution a copious white precipitate of ammonium-magnesium phosphate is thrown down. The aqueous solution when acidulated with hydrochloric acid gives, with barium chloride, an abundant white precipitate of barium sulphate.

The specific gravity of the mineral, at 15° 5 C. was found to be 1·757, and an analysis of selected material, which however still contained some included silica, gave the following results:—

Sulphur trioxide	34·52
Magnesia	17·15
Water	46·42
Insoluble matter (silica)	1·78
	99·87

Omitting the included silica it will be found that the composition of the mineral agrees very closely with that required for the hexahydrate of sulphate of magnesium, $MgSO_4 6H_2O$, which hitherto has only been known as a product of the laboratory. The agreement will be made plainly evident by a reference to the following figures, in which column I. represents the composition of the mineral under discussion, and column II that required by theory for the normal hexahydrated salt:—

	I	II
Sulphur trioxide..	35·19	35·09
Magnesia..	17·48	17·54
Water	47·33	47·37
	100·00	100·00

As this is the first instance in which this salt has been recorded as occurring in a state of nature, this substance is entitled to be regarded as a new mineral, and the name hexahydrite is proposed for it, in allusion to the six molecules of water which enter into its composition.

AWARUITE, ALMANDITE, AND MAGNETITE.

(1.) In the Summary Report of the Geological Survey for 1908, page 168, reference was made to a specimen of nickel-iron alloy found in the sluice boxes of the gold washings of Hoole cañon, Pelly river, Yukon. At the time of writing the report

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Photo by Miss W. K. Bentley.

Fig. 7. Grains of Awaruite from Hoole cañon, Pelly River, Yukon. Magnified 6 diameters.

mentioned, the examination of the specimen was incomplete and the term ferro-nickel was applied to it provisionally. The complete examination now warrants its being placed definitely under the species awaruite. It was found amongst the heavier materials carried down in the sluice boxes of the locality mentioned, and attracted attention by reason of its inertness towards the amalgam plates used for the extraction of the gold. It was thought that it might possibly be platinum.

As received by the writer from Mr. Joseph Keele, of the Geological Survey, who submitted it for examination, it constituted only a fraction of one per cent of the concentrates, which, with the exception of the mineral under consideration and a few quartz grains, consisted of fine grains of magnetite, and a pale reddish garnet, which on close examination has proved to be almandite.

The awaruite is in the form of irregularly shaped grains, a very few of which simulate an octohedral form. Some of the grains are more or less flattened, and at times show an indistinct lamination. A few are elongated into wire or rod-like forms, while others are cone-shaped. Few of the individual grains exceed a millimetre in diameter, while the majority are much smaller. The largest grain observed had a diameter slightly in excess of two millimetres. Some of the rod-like forms had a length of three millimetres, with a thickness of much less than a millimetre.

In order to determine the presence or absence of a definite crystalline structure a few of the larger grains were mounted in sealing-wax and ground with emery on a glass plate until they showed well polished surfaces. These were then exposed for intervals of fifteen minutes to the vapours of dilute nitrohydrochloric acid. By this means the progressive action of the acid vapours could be conveniently observed. At first several series of concentric rings were developed, and as the corrosive action progressed it could be seen that the grains were made up of a number of minute particles, each of which enclosed a nucleus of a white siliceous material, thus indicating a sort of sporadic structure for the individual grain.

The grains as they occur in the sand have a pale yellowish tarnish, which is easily removed by agitation and rubbing in alcohol, revealing a steel-grey colour as that of the mineral. They are malleable and under the hammer readily flatten into thin scales, and are somewhat sectile, yielding rather readily to the impress of an ordinary steel knife-blade. They are also strongly magnetic, and occasionally exhibit marked polarity, not only clinging together, but also to the grains of magnetite with which they are associated, as well as to articles of steel with which they may be brought into contact. Hydrochloric acid acts on the mineral, but slowly even on warming; but with dilute nitric acid the mineral readily passes into solution, even in the cold.

The specific gravity of the mineral, at 15·5° C, was found to be 7·746, while the composition was found to be as follows:—

Nickel	74·34
Iron	21·35
Cobalt	1·34
Copper	0·48
Phosphorus	0·08
Sulphur	0·03
Insoluble matter	1·72
	99·34

After deducting the insoluble matter the centesimal composition of the alloy is found to be as follows:—

Nickel	76·16
Iron	21·87
Cobalt	1·37
Copper	0·49
Phosphorus	0·08
Sulphur	0·03
	100·00

Magnetite.—In view of the association of magnetite with the awaruite it became of interest to determine whether the former might or might not contain metallic constituents other than iron. Accordingly 2·75 grammes were submitted to examination, but no unusual constituent was found to be present. The specific gravity of the magnetite, at 15·5° C, was found to be 5·065.

Almandite.—The almandite, with which the awaruite and magnetite just described are associated, is in the form of minute angular grains, frequently rounded on the edges. They have a pale reddish colour, and vitreous lustre. They were found to have a specific gravity of 3·991, at 15·5° C, and on analysis to possess the following composition:—

Silica	37·7
Alumina	21·1
Ferric oxide	2·4
Ferrous oxide	31·9
Manganous oxide	1·5
Magnesia	5·1
Calcium monoxide	none
	99·7

AXINITE.

(2.) The material for this analysis was collected by Mr. Charles Camsell of the Geological Survey, at Nickel Plate mountain,[1] Osoyoos mining division, Yale district, British Columbia, during the season of 1908, and was referred to in the Summary Report for that year at page 168. It occurs on the western slope of the mountain, in the form of dark hair-brown crystals and crystalline masses at the contact between monzonite and sedimentary beds.

This material was selected with great care, and consisted entirely of small fragments of crystals free from any associated minerals. These fragments were subtranslucent and possessed a highly vitreous lustre; they were found to have a specific gravity of 3·296, at 15·5° C, and on analysis to possess the following composition:—

Silica	42·18
Boron trioxide	5·22
Alumina	18·12
Ferric oxide	0·98
Ferrous oxide	7·20
Manganous oxide	3·89
Zinc oxide	0·09
Calcium monoxide	19·91
Magnesia	1·43
Water	0·35
	99·37

Mr. R. L. Broadbent has been occupied throughout the year solely in museum work. Much of his time has been taken up with the listing and packing of the mineral collections preparatory to removal to the Victoria Memorial Museum, matters which have demanded the utmost care and vigilance.

Very considerable additions have been made to the Canadian and foreign collections in the mineral section of the Museum, as will be seen from the accompanying lists.

ALTERATION PRODUCT AFTER AMPHIBOLE.

(3.) At various times recently there have been brought to this office for examination and report, from different localities in the Gatineau valley, in the Province of Quebec, specimens of waxy or clay-like alteration products, all bearing, in outward characters at least, a very close resemblance to each other. They also appear, as far

[1] For a full description of this occurrence see Memoir No. 2, Geological Survey Branch, Department of Mines, Canada, page 148.

as could be determined from qualitative chemical analysis, to be of nearly identical chemical composition. In most cases, however, the material was either too small in amount or too impure to admit of quantitative examination.

The specimen below referred to was brought to this office for examination by Mr. W. A. McIsaac, and was collected on property belonging to Mr. P. Lannagan, situated in the township of Egan, Ottawa county, Que., about 15 miles northwest of River Desert post-office. As previously indicated, however, similar material has been noticed elsewhere in the district, particularly in the townships of Aylwin and Wright.

The material is closely associated with and very generally mixed with more or less very dark green or greenish-black amphibole, from which it has undoubtedly been derived by alteration; the amphibole and its derivative occur in scattered patches in rocks composed of coarse masses of white quartz and feldspar.

It has a characteristic wax-like texture and slightly soapy feel, and adheres strongly to the tongue; the colour, which is uniform throughout, is a pale yellowish-grey.

Before the blow-pipe it fuses with great difficulty only on thin edges; in the closed tube it yields a large amount of water, and with no perceptible change in the colour of the material. It is decomposed with separation of gelatinous silica by dilute hydrochloric acid, even in the cold.

Its specific gravity, at 15·5° C, was found to be 2·162, and after deducting 5·31 per cent of admixed unaltered amphibole its composition was found to be as follows:—

Silica	42·76
Alumina	4·32
Ferric oxide	2·57
Calcium monoxide	1·92
Magnesia	25·30
Water	23·13
	100·00

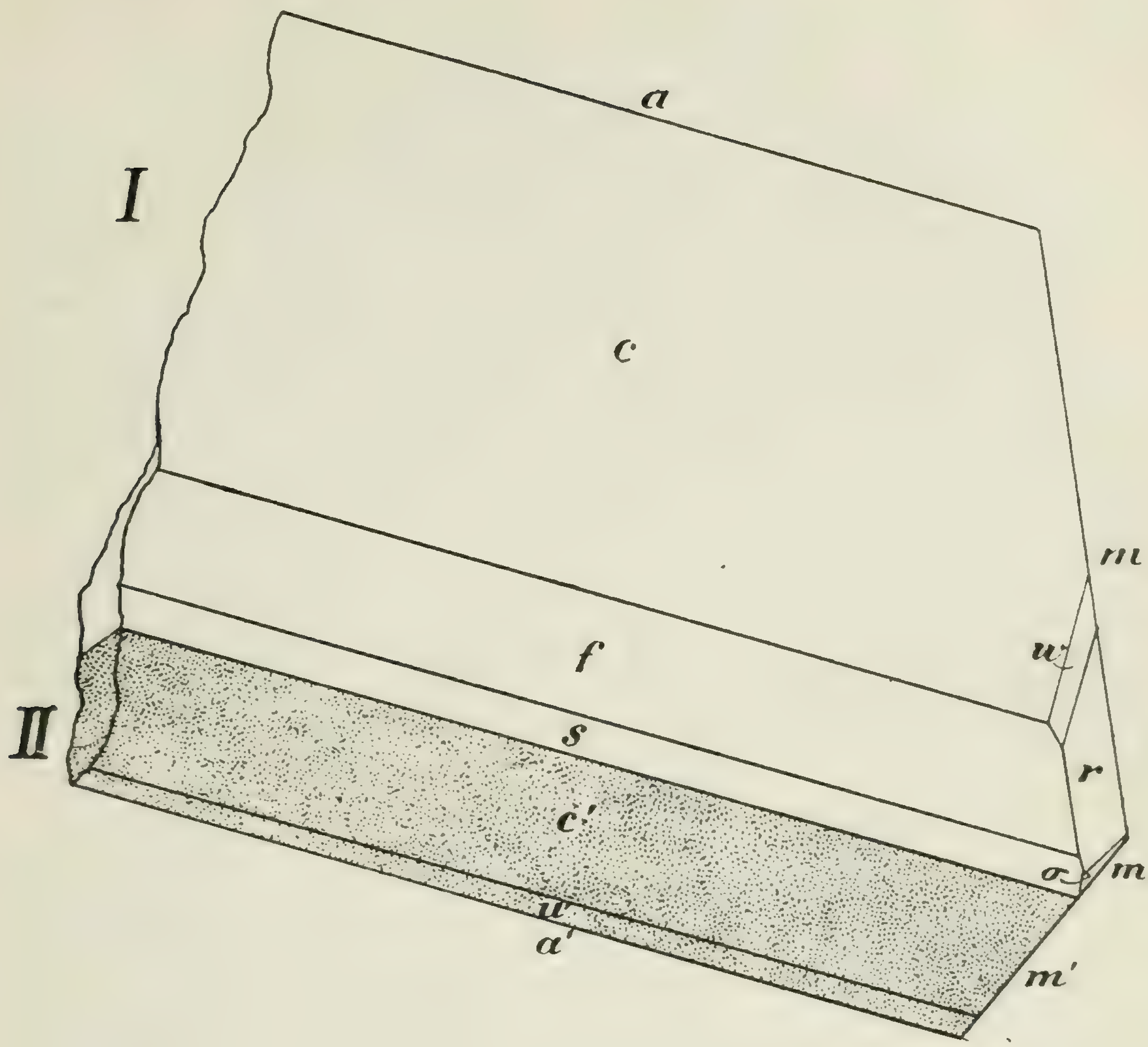
The above composition agrees closely with that of saponite, to which species the material is probably referable, although it displays some inconsistencies in respect of its behaviour before the blowpipe, and with reagents.

LINARITE.

(4.) Some very fine specimens of this mineral were collected by Mr. O. E. Leroy, of the Geological Survey, during the season of 1909, at the Beaver group, Beaver mountain, Slocan, West Kootenay, British Columbia. It occurs, along with anglesite, in individual crystals and in crystal groups, along the walls of cavities in an ore body consisting of coarsely crystalline galena and chalcopyrite. Some of the crystals attain a length of nearly half an inch; one very perfect one has been the subject of crystallographic investigation by Professor V. Goldschmidt, of Heidelberg, Germany, and Professor W. Nicol, of Queens University, Kingston, Ontario, the results of which are inserted below. The crystals have a vitreous lustre and a deep azure blue colour. Some of the thin tabular forms are subtransparent.

The specific gravity, at 15·5° C, was found to be 5·23, and the chemical composition as follows:—

Lead sulphate	75·17
Cupric oxide	19·88
Water	4·73
	99·78



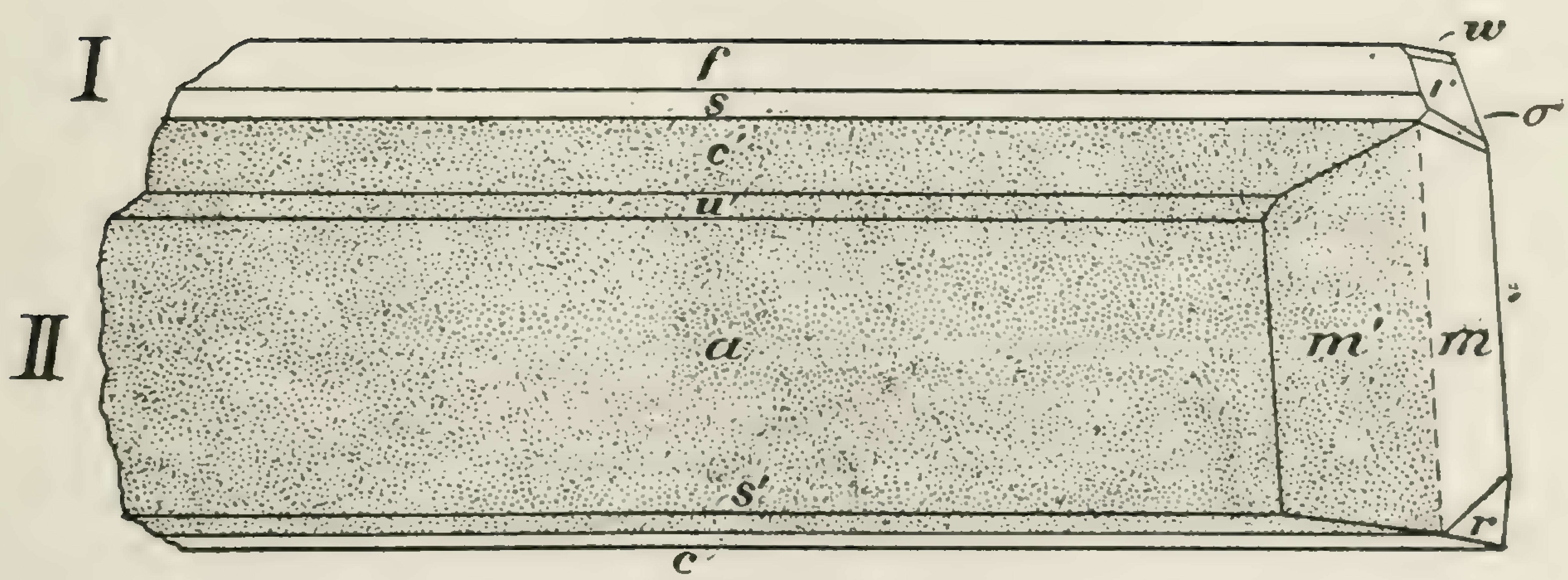


Fig. 5.

Drawn by W. Nicol.

Fig. 7.—Crystal of Linarite, Beaver Group, Beaver Mountain, Slocan, West Kootenay, B.C.

The measurement was carried out under the direction of Prof. Goldschmidt, in Heidelberg, and the drawings were made by Prof. Goldschmidt's assistant, Mr. R. Schroeder.

It is probable that these linarite crystals are the first from a Canadian locality to be described. They rest in a cavity surrounded by galenite, copper pyrites, and the decomposition products of these, viz., limonite and anglesite. Since it was not permissible to remove the crystals from the mass, it was necessary to carry out the measuring operations *in situ*. This was satisfactorily accomplished on the two-circle goniometer.

An almost perfect crystal of the dimensions 3 × 2 × 6 mm. was measured. The beautiful blue crystal which is elongated in the direction of the orthodiagonal rests with the end of the ortho axis protruding from the druse and presents, therefore, a prismatic habit. The other crystals in the druse possess the same habit. The crystal is a twin according to the well known twinning law for linarite, viz., twinning-plane and combination face, the front pinacoid a $=\infty$ 0 (101). Fig. 1[a] shows a top view of the crystal and fig. 1[b] a perspective view. The faces are drawn to correspond as nearly as possible with the original crystal.

The individual I (behind in the figure) is larger and richer in faces than the individual II (in front). Both meet in a very flat reentrant angle formed by the faces s=o (001) of individual I and $\acute{c}= -10$ ($\bar{1}01$) of the individual II. The angle s a $\acute{c}$ measured, is 2° 8′ (calculated 2° 34′). The plane of junction of the two individuals is plainly visible as a fine sharp line indicated in the figure by dotted lines.

OBSERVED FORMS.

Letter	s	a	m	σ	u	f*	c	r	w
Symbol	o	∞o	∞	02	+10	$-\frac{1}{4}$o	−10	−1	$-1\frac{1}{2}$
Miller	001	100	110	021	101	$\bar{1}04$	$\bar{1}01$	$1\bar{1}1$	$\bar{2}12$

COMBINATION.

Crystal I	s	a	m	σ	•	f	c	r	w
Crystal II	s	a	m	•	u	•	c	•	.

All the faces are smooth and brilliant and give good signal reflections.

This twin crystal shows a new form: f $= -\frac{1}{4}$o (101). The facet is broad, well-bordered, and gives an excellent signal reflection.

Measurement and calculation correspond well.

Measured	= 90°	$\rho = 8°\ 22'$.
Calculated	= 90°	$\rho = 8°\ 23'$.

The form is, therefore, assured.

It may be here noted that linarite has been observed in a specimen brought in lately from Table mountain, near Atlin lake, British Columbia, by Mr. D. D. Cairnes, of the Geological Survey. In this instance the crystals, which are small, occupy a small cavity in a specimen consisting of a calcareous ganguestone more or less impregnated with galena and chalcopyrite.

DIAMOND.

This mineral has been found as a constituent of a rock occurring on the eastern slope of Olivine mountain, about 2 miles to the southward of Tulameen river, Yale district, British Columbia. The specimen in which it has been observed was collected by Mr. Charles Camsell during the season of 1910, and at his request has been under examination with a view to determining the mineralogic constitution of the chromium ore which it contains.

The rock is essentially an altered peridotite, nearly all of the original olivine being now represented by a massive and somewhat easily friable serpentine, varying in colour through a pale yellow to a dirty yellowish white. Through this rock the chromium ore is distributed in the form of small veinlets and scattered patches and grains. Superficially the chromium ore does not present any unusual characters, and responds to the ordinary tests for chromite; a preliminary examination made upon some of the finely pulverized material which had been separated by means of a heavy solution showed, however, that it was readily separable into two portions—a magnetic and a non-magnetic portion—by the aid of an ordinary magnet. These two portions were found to be approximately equal in amount.

The non-magnetic portion was first submitted to analysis, and in order to effect its decomposition it was fused with about four times its weight of carbonate of sodium, for several hours; after cooling, the melt was digested in water, and the sodium chromate which had been formed was removed by filtration and washing; the insoluble portion was then digested with hydrochloric acid to remove oxides of iron, magnesium, etc.; there still remained a very considerable amount of a brownish residue, which was subjected to a repetition of the process just described, but without any sensible diminution in its amount, which was found to equal 3·63 per cent of the sample employed. A weighed sample of the magnetic portion was then, subjected to similar treatment, and a residue identical in character was obtained, but equalling 9·06 per cent of the sample employed. This residue was then tested with hydrofluoric acid, but this reagent had no effect upon it. Fusion with bisulphate of potassium likewise produced no result; fusion with peroxide of sodium resulted in the formation of a black graphitic material. Its specific gravity could not be determined satisfactorily, but by means of a solution of the double nitrates of thallium and silver it was found to be in excess of 3·3. Under the microscope the residue was seen to be made up of sharply angular particles, many of which exhibited a distinct octohedral form, and, as shown by Mr. Camsell, were perfectly isotropic; they were found to be very hard and when mounted on a small piece of wood scratched sapphire with facility, thus indicating a hardness of 10, which is that of diamond. They have been found by Mr. O. Higman, chief electrician of the Department of Inland Revenue, to transmit the X rays without interruption, a fact which in itself alone points conclusively to the identity of this substance with the mineral diamond.

Several attempts have been made to extract the diamonds in unbroken forms by acting on large quantities of coarsely broken material with various solvent reagents, but with indifferent success. It has been found that when a very active reagent, such as bisulphate of potassium, is employed to remove the chromite, the individual crystals crumble into dust from internal strain before they can become accustomed to the changed conditions incident upon their release from the matrix in which they have been enclosed. Better results have been obtained by the use of carbonate of sodium, but the action is very slow. In a number of instances while using this reagent the interesting phenomenon was observed of the breaking up of individual diamonds from internal strain upon being released from the matrix.

The largest individuals so far extracted do not exceed in size that of a pin head; some of them are perfectly colourless while the others exhibit various brownish tints.

In one large sample of the rock which was worked down for diamonds, one or two particles of native gold, and several particles of native platinum were found accompanying the diamond residuum.

Mr. A. T. McKinnon has, as in former years, rendered conscientious service in assembling and despatching the educational collections which have been distributed by the Department. During the season just closed he has collected some fourteen tons of material for use in these collections. This is in addition to three tons which have been purchased for the same purpose.

The thanks of the Department are due to the following gentlemen for much kindly assistance and donations of material in connexion with the educational collections: Mr. M. J. O'Brien, Renfrew, Ontario; Mr. Bush Winning, Ottawa, Ontario; Mr. Thomas Morrison, Bancroft, Ontario; Mr. John Collins, Bancroft, Ontario; Mr. Charles Bulpit, Bryson, Quebec; Mr. J. H. Gillespie, Parrsboro, Nova Scotia; Mr. John Higson, Stellarton, Nova Scotia; Mr. Harry Piers, Halifax, Nova Scotia; Mr. George Stewart, Springhill, Nova Scotia; Mr. E. R. Reader, Bryson, Quebec; Mr. Wm. Parker, Buckingham, Quebec. Mr. Geo. H. Aylard, New Denver, British Columbia, has also, at the request of Mr. O. E. Leroy, donated 1,000 pounds of pure galena from the Standard mine near Silverton.

The following additions have been made to the Canadian division of the mineral section of the Museum:—

DONATIONS.

Amalgamated Asbestos Corporation, Limited, Montreal, Quebec—

Large specimen of asbestos ore from the British Canadian mines, Thetford, Megantic county, Quebec.

Mr. A. C. Andresen, Ottawa, Ontario—

Specularite from Foster, Brome county, Quebec.

Mr. D'Arcy Arden, Ottawa, Ontario—

Native copper, bornite, pyrrhotite, and chalcopyrite from the head of White river, Yukon.

Dr. A. E. Barlow, Montreal, Quebec—

Emplectite from the Floyd mine, Buck township, Nipissing district, Ontario; and the following products of the ores of the Cobalt mines: porcelain plate coloured cobalt-blue, cobalt anode, cobalt speiss, slag from smelting cobalt speiss, coarse cobalt speiss, finished cobalt speiss, blue cobalt silicate, cobalt chloride, cobalt nitrate, cobalt oxide, cobalt sulphate.

Captain Bartlett (ss. *Roosevelt*) per Captain J. E. Bernier—

Cherty quartzite from Cape Columbia, Ellsmereland.

Mr. W. A. Begg, Haileybury, Ontario—

Quartz with pyrite, magnetite, and native gold, from the north half of lot 6, concession III of the township of Tisdale, Sudbury district, Ontario.

Mr. George Clarke, Sandon, B.C.—

Massive stibnite, Alturas claim, North Fork Carpenter creek, Slocan district, West Kootenay, B.C.

Mr. Fritz Cirkel, Montreal, Quebec, per Dr. Eugene Haanel—

Collection of asbestos and asbestos products of the Thetford mines, Megantic county, Quebec.

Mr. M. T. Culbert, Cobalt, Ontario—

Claucodot and galena from the O'Brien mine, Cobalt, Ontario.

Mr. Louis St. Cyr, Ottawa, Ontario—

Native sulphur from township 80, range 2, west of the 6th meridian, Alberta; agate pebbles from Peace river, Alberta; lignite from township 77, range 6 west of the 6th meridian, Alberta.

Mr. E. T. Ellis, Ottawa, Ontario—

Concretions of hematite from Clifton, Gloucester county, New Brunswick.

Mr. R. R. Hedley, Victoria, British Columbia—

Native copper with associated rocks, from Battle bluff, opposite Cherry creek, Kamloops, British Columbia.

Mr. George B. Hull, Ottawa, Ontario—

Molybdenite from Turnback lake, Abitibi district, Quebec.

Mr. E. A. Jacobs, Victoria, British Columbia—

Massive pyrite from the B. C. Copper Company's property, Wellington camp, Grand Forks, West Kootenay, British Columbia.

Mr. S. R. Lanigan, St. Réné de Amherst, Quebec—

Fine group of quartz crystals from Amherst township, Ottawa county, Quebec.

Messrs. Lindsay Bros., London, Ontario—

Sphalerite from lot 30, concession III, Albermarle township, Bruce county, Ontario.

Maritime Oilfields Company, Moncton, New Brunswick—

Petroleum from No. 3 and No. 5 wells on the Petitcodiac river, 10 miles south of Moncton, New Brunswick.

Mr. A. J. Morrow, Eganville, Ontario—

Beryl from Lynedoch township, Renfrew county, Ontario.

Mr. Morley Ogilvie, Ottawa, Ontario—

Auriferous quartz from the Dr. Reddick mine, Larder lake, Nipissing district, Ontario.

Mr. D. S. Sawyer, Ottawa, Ontario—

Large specimen of gold ore from the Dr. Reddick mine, Larder lake, Nipissing district, Ontario.

Mr. L. A. Smart, Winnipeg, Manitoba—

Chemawinite from Leaf lake, Saskatchewan.

Mr. A. D. Tennant, Stewart, British Columbia—

Pyrite and chalcopyrite from Montrose tunnel, and chalcopyrite with pyrite from Red Cliff tunnel, Stewart, Portland canal, British Columbia.

Mr. Wm. Tomlinson, New Denver, British Columbia, per Mr. O. E. Leroy—

Slickensided galena showing torsion cracks from the Standard mine, Fourmile creek, West Kootenay, British Columbia.

Mr. J. T. C. Thompson, Ottawa, Ontario—

Two specimens of native silver with erythrite; one specimen of crystallized quartz with native silver; one specimen of aplite; all from the Lucky Godfrey mine, Willet township, Nipissing district, Ontario.

COLLECTIONS MADE BY OFFICERS AND EMPLOYES OF THE DEPARTMENT OF MINES.

Mr. R. W. Brock—

Specimens of auriferous quartz from the Timmins and Cragg mines, Porcupine, Nipissing district, Ontario.

Mr. D. D. Cairnes—

Tetrahedrite from the Brothon claim, Hoboe creek; stibnite from Taku arm; galena and chalcopyrite in quartz from Munroe mountain; galena, chalcopyrite, and tetrahedrite from the White Moose claim; ore from the Laver-

dière group; ore from Crater creek; tetrahedrite in quartz from the Alvine claim; ore from the Reds group; tetrahedrite and chalcopyrite from the Dundee claim; galena, chalcopyrite, and linarite from Table mountain; gold ore from the Engineer mine; ore from the Lawsan group, Bighorn creek; ore from the Holy Cross claim, Hoboe creek; native copper from Copper island, Atlin lake; all of these localities are situated in the Atlin mining division of British Columbia.

Mr. Charles H. Clapp—

Finely vesicular rock (lava?) from Village valley, Mayne island, B.C.

Mr. W. H. Collins—

Native iron found in gossan at Smoothwater lake, Gowganda, Nipissing district, Ontario; native silver from the Lucky Godfrey mine, Willet township, Nipissing district, Ontario.

Mr. D. B. Dowling—

Lower Cretaceous sandstone impregnated with magnetite, from Pine creek, a branch of Waterton river, Alberta; series of coals from the Jasper Park collieries, eight samples; coal from Keywood claim, Brulé lake, Jasper park, Alberta; lignite from Tofield, Alberta; lignitic coal, near mouth of Oldman river, Athabaska river, Alberta; coal from near Muskeg river, a branch of Smoky river, section 2, township 57, range 7, west of 6th meridian, Alberta, received from Mr. J. R. Akin, D.L.S.

Mr. J. A. Dresser—

Idocrase from the American Chrome Company's property, Black Lake, Megantic county, Quebec.

Mr. Joseph Keele—

Series of bricks: Red Cliff Brick Company, Red Cliff, Alberta; Alberta Portland Cement Company, Sandstone, Alberta; Edmonton Brick Company, Edmonton, Alberta; P. Anderson and Co., Edmonton, Alberta; Eureka Coal and Brick Company, Estevan, Saskatchewan, two specimens; the Stephens Brick Company, Portage la Prairie, Manitoba, two specimens.

Mr. O. E. Leroy—

Sphalerite from the Lucky Jim mine, Slocan, West Kootenay, British Columbia; linarite, anglesite, galena, and chalcopyrite from Beaver mountain, Slocan, West Kootenay, British Columbia; quartz crystals, siderite, and pyrite from the Ohio claim, Lyell creek, Slocan, West Kootenay, British Columbia; mispickel in quartz-schist from Marcus and Gilbert's claim, Poplar, Lardeau, West Kootenay, British Columbia; quartz replacing limestone, from the Mother Lode mine, Deadwood, British Columbia.

Mr. A. T. McKinnon—

Olivine and spinel from lot 52, range V, Bigelow township, Ottawa county, Quebec.

Mr. H. Ries—

Series of bricks: Minto, Queens county, New Brunswick, two specimens; Salmon bay, Grand lake, Queens county, New Brunswick, two specimens; Flower cove, Grand lake, Queens county, New Brunswick, three specimens; Albert mines, Albert county, New Brunswick; Murphy brook, Middle Musquodoboit, Halifax county, Nova Scotia, three specimens; Smalls brook, Woodbourne, Pictou county, Nova Scotia, two specimens; Brook's brickyard, New Glasgow, Pictou county, Nova Scotia, two specimens; Bailey brook, Pictou county,

Nova Scotia, two specimens; Joggins, Pictou county, Nova Scotia; Coxheath, Inverness county, Nova Scotia, three specimens; Inverness, Inverness county, Nova Scotia, three specimens; Port Hood, Inverness county, Nova Scotia; Pugwash, Cumberland county, Nova Scotia; Shubenacadie, Cumberland county, Nova Scotia; Cranberry head, Cape Breton, Nova Scotia, two specimens; Glace bay, Cape Breton, Nova Scotia; Toronto mine, Sydney, Eden Siding, Ashby, Port Morien, and McKinnon harbour, Cape Breton county, Nova Scotia, each one specimen.

Mr. Morley Wilson—

Molybdenite and beryl from Turnback lake, Abitibi district, Quebec.

PURCHASES.

Boulder creek, Atlin, British Columbia, three gold nuggets; series of specimens of alluvial gold from locations in Atlin, B.C., Yukon, and Alaska, as follows: Dominion creek (4 above), Yukon; Gold hill, Yukon; McKee creek, Atlin; Bear creek (8 below), Yukon; Lower Jack Wade (Fortymile river), Alaska; Gold-run (22), Yukon; Eldorado (No. 6), Yukon; Last Chance creek, Yukon; Dominion creek (4 above), Yukon; Bonanza creek (38 above), Yukon; Sulphur (31 above), Yukon; Monte Cristo, Yukon; Lovett gulch, Bonanza creek, Yukon; Bonanza creek (26 above), Yukon; Bonanza bench (20 above), Yukon; French Hill, Yukon; Lower Dominion (13 above), Yukon; Hunker (17 above), Yukon; Wright creek (13 above), Yukon; Pine creek, Atlin; Lower Dominion (4 above), Yukon; Poverty Bar (12 below), Bonanza), Yukon; Upper Dominion (4 below), Yukon; Sulphur (17 below), Yukon; Victoria gulch (No. 2), Yukon; Seventymile, Yukon; Monte Cristo gulch, Bonanza creek (8 below), Yukon; Gold-run (39 and 40), Yukon; Bonanza bench (30 below), Yukon; McQuesten, Yukon; Hunker (11 below), Yukon; Hunker (below) Yukon; Anvil creek, Nome; Chicken creek, Fortyninemile river, Alaska; Anvil creek, Nome.

Cobalt, Nipissing district, Ontario: Cobaltite from the Evans mine; smaltite and native silver from the Coniagas mine; native silver from the Silver Leaf mine; native silver from the Nipissing mine.

The following additions have been made to the foreign division of the mineral section of the Museum.

DONATIONS.

Mr. R. A. Daly, Boston, Massachusetts, U.S.A.—

Specimen of Pele's Hair collected by Mr. H. E. Wilson, Homapo, at a point 4 miles south of Kilauea crater, Hawaii.

Miss M. B. McLeod, Tarbustad, South Africa, per Mr. W. J. Wilson—

Quartz, pseudomorph after crocidolite, from Prieska, Transvaal; mica-schist from Buluwayo, Rhodesia.

Mr. Justice Prows, St. Johns, Newfoundland—

Coal from a location 14 miles inland from Forteau, Straits of Belle Isle, Newfoundland-Labrador.

Mr. Thomas Vanes, Ottawa, Ontario—

Kauri gum and coal from Huntley mine, New Zealand; auriferous quartz from Waihi mine, New Zealand.

EXCHANGES.

Mr. W. E. Christianssen, Keystone, South Dakota, U.S.A.—

Series of specimens from the Black hills, South Dakota, U.S.A., as follows:—Amblygonite from the Spodumene Lode mining claim; cuprocassiterite from the Etta claim; spodumene; lepidolite from the Spodumene mining claim; leucopyrite from the Bob Ingersoll claim; graphite from an abandoned tin deposit; wolfram ore from the Seminole claim; apatite from the Spodumene mining claim; cassiterite; beryl from an old abandoned tin prospect; rose quartz; cassiterite and lollingite from the Etta mine; petalite from the Spodumene mining claim; tin ore from the Road Agent group; garnets in slate, common in district; chalcopyrite from the Christianssen Consolidated Copper Company's prospect; triphylite from the Nickel Plate mine; pyritic ore, common in veins and ore-bodies of the district; columbite from the Bob Ingersoll mine.

Mr. P. Walther, 44 Sanderson Road, Fesmond, Newcastle-on-Tyne, England—

Miscellaneous collection of minerals as follows: olivine bomb, Eifel, Germany; augite bombs, Eifel, Germany; cuprite and chrysocolla from Copiapo, Chili; native coke, Scotland; Atacamite from Chuquaiamata, Chili; sulphate of magnesia and copper from Chuquiamata, Chili; witherite from Fallowfield, Northumberland, England; native tantalum from the Altai Mountains, Siberia; copiapite with chalcanthite from Antafagasta, Chili; barytocalcite from Alston Moor, Cumberland, England; brochantite from Chuquiamata, Chili; trona (white and pink) from Mogard lake, East Africa; adamite from Chili; zincocalcite with olivinite from Chili; witherite from Alston Moor, Cumberland, England; alstonite from Fallowfield, Cumberland, England; barite from Fallowfield, Cumberland, England; delvauxite from Follinggraben, Steirmark, Austria; manjak from Trinidad; malachite from Chili; dioptase from Copiapo, Chili; chalcanthite on brochantite from Chuquiamata, Chili; chalcopissite from Chili.

PURCHASE.

Native gold from Idaho, U. S. A.

PALÆONTOLOGICAL DIVISION.

(Lawrence M. Lambe.)

During the first half of the year, while continuing to fulfil the duties of Palæontologist and Zoölogist, much of my time was devoted to re-examining collections of invertebrate fossils, described by the late Dr. Whiteaves, and others, for the most part in Geological Survey publications, but which had not been exhibited through lack of museum space. It was found necessary to go over these collections carefully, labelling the specimens as determined, and to recognize and indicate the type and figured material, so as to allow of the collections being catalogued.

Other collections which had been reported on in a more general manner, principally by Dr. Whiteaves, and which it was not necessary to catalogue, were labelled and set aside, or boxed up and placed in storage.

A considerable portion of my time has been given to supervising the cataloguing of the exhibited fossil collections, and of those collections reported on and described, but not as yet placed on view, which was begun in November, 1909, by Mr. W. J. Wilson, assisted by Miss A. E. Wilson, and completed in October of this year. The fossils are catalogued as now exhibited, viz., zoölogically according to formations. Running numbers beginning at one hundred, have been used, and each specimen has been numbered in oil paint; type specimens in addition bear a small red circle in paint; cotypes are indicated by a green circle, and figured specimens by a red cross. In the case of a number of specimens, on one tablet, of the same species and from the same locality, letters follow the number, as for example, 101 *type,* other specimens on the same tablet 101*a*, 101*b*, etc. In the card catalogue, each card, corresponding in number to the specimen to which it refers, gives the following information, viz., the genus and species, the locality, formation, name of the collector with the date of collection, also whether the specimen is a type, cotype, or figured specimen, etc., with any further information thought desirable. The Geological Survey is now, for the first time, in possession of an accurate and comprehensive record of its described collections of fossils in the shape of a card catalogue, which later can be used in connexion with the installation of these collections in the Victoria Memorial Museum, in whatever manner they may be arranged.

On the completion of the above card catalogue, and with a view to the publication of a catalogue of the type and figured specimens of fossils now in the possession of the Geological Survey, Mr. Wilson and Miss Wilson, under the writer's and Dr. Raymond's supervision, began, and are now engaged in work preliminary to a compilation of this character. With the catalogue of the fossil types, etc., will appear a complete bibliography of all palæontological writings based on specimens belonging to the Geological Survey.

In view of the early date at which the collections might be removed to the new building it was considered expedient to have the large, described, but as yet unexhibited, collection of vertebrates from the Judith River formation of Alberta (which includes many generic and specific types) packed and ready for removal. It was necessary to spend some time in repairing many of the larger fragile specimens of this collection before they could be placed in boxes. The collection as a whole is now ready for removal, and can be easily handled without danger of breakage. This collection of vertebrates, together with those of invertebrates already mentioned, and some recent zoölogical material, fill seventy-five large boxes.

This autumn, labels for use in the Victoria Memorial Museum, have been prepared for all the fossil vertebrates to be exhibited.

A collection of thirteen specimens of Pelecypoda (mostly casts of the interior) from Texada island, B.C., collected by Mr. R. G. McConnell in 1909, was received from him in March of this year and reported on. Eight species of seven genera are represented in this collection, which was made from an outlier of Cretaceous rocks half a mile east of Cook bay.

The fifth part of Contributions to Canadian Palæontology, vol. III (quarto) on 'Palæoniscid Fishes from the Albert Shales of New Brunswick,' was published in August of this year.

A short paper on a recent discovery in connexion with the parietal frill of the Cretaceous dinosaur *Centrosaurus apertus* was prepared and published in the December number of the Ottawa Naturalist.

A Bibliography of Canadian Zoölogy for 1909 (exclusive of Entomology), was written during the early part of the year, and presented at the annual meeting of the Royal Society of Canada for publication.

ADDITIONS TO THE PALÆONTOLOGICAL AND ZOÖLOGICAL COLLECTIONS DURING 1910.

Mr. Lambe reports the following accessions to the Survey collections:—

Received from members of the Geological Survey as follows—

McConnell, R. G.—

Twelve specimens of Pelecypoda, collected in 1909, from an outlier of Cretaceous rocks, half a mile east of Cook bay, Texada island, B.C.

Wilson, W. J.—

Six pieces of carbonaceous limestone holding remains of amphibians, from a sigillarian stump, from the Coal Measures near Joggins mines, N.S.

Small collection of plants from the Coal Measures at Joggins mines, N.S.

About 1,000 specimens of Carboniferous plants from Minto, Sunbury county, N.B.

Leach, W. W.—

Thirteen specimens of *Taxodium distichum miocenum*, etc., from Omineca ming division, B.C., Driftwood river, 7 miles from its mouth. Tertiary (Oligocene).

Two specimens of fossil plants from Bulkley river, B.C., about 10 miles from its mouth.

Camsell, C.—

Two specimens of Tertiary plants from White lake, Okanagan valley, B.C.

Received from other sources—

By presentation:—

Grant, Col. C. C., Hamilton, Ont.—

Twenty-one fossils from the glaciated chert beds of the Niagara formation at Hamilton, and one fossil from the Clinton formation at the same place. Four sponges in chert nodules from the Niagara formation at Hamilton, Ont.

Wilmer, Lieut.-Colonel L. Worthington, Lothian House, Ryde, England—

112 English Cretaceous and Tertiary fossils, mostly pelecypods and gasteropods.

Farmer, Wilfred, near Indian Head, Sask.—

Anterior caudal vertebra of a Mosasaurian reptile, obtained from gravel at a depth of 20 feet below the surface, in digging a well, about 20 miles south of Indian Head, and 4 miles north of Odessa, on the line of the Canadian Northern railway. Judging from shale adhering to the bone it is probable that the specimen comes from the upper shales of the Pierre formation.

St. Cyr, J. B., per Dr. E. G. D. Deville, Surveyor General, Ottawa—

An imperfect specimen of *Scaphites ventricosus?* (Meek), and a fragment of impure limestone showing cone-in-cone structure, collected by Mr. St. Cyr, in 1909, on Brulé river, a tributary of Peace river, about 25 miles south of Dunvegan, Alta.; of Cretaceous age and probably from the Benton formation.

Altschel, J.—

Three seperate fragments of *Baculites oratus,* Say, from Athabaska river, 36 miles below Athabaska Landing; upper Cretaceous (?Pierre-Foxill formation).

Brown, R. H., 36 Kent street, Halifax, N.S.—

One photograph of fossil fern (*Neuropteris cordata* or *angustifolia*) from the roof of main seam of coal, Princess pit (Sydney No. 1), Sydney mines, 1903. Coal measures.

Conroy, H. A.—

Part of a molar tooth of Mammoth, from a clay bank on Loon river, 40 miles from its mouth, a tributary of Peace river, Alta.

Evans, W. B., Minto, Sunbury county, N.B.—

Small collection of Carboniferous plants from the Rothwell Coal Co.'s mine, Minto, N.B.

Adami, Professor J. G., McGill University, Montreal, Que.—

One specimen of a fish, part of the crustacean, and a fragment of a cephalopod from the lithographic stone deposits of Bavaria (Jurassic).

Morrison, John M., and Bannerman, John B., Carcross, Yukon—

Through an error in last year's Summary Report a fine skull of the Pleistocene horse, from No. 34, Gold-run creek, Yukon, was stated to have been acquired by the Geological Survey by purchase, whereas it was presented to the Museum by Messrs. Morrison and Bannerman.

By purchase:—

A very large specimen of *Aphrocallistes whiteavesianus,* Lambe, brought up on a cod hook near Nanaimo, B.C., and having the following dimensions: breadth 21 inches, height 15 inches, thickness from back to front 15 inches. A small fragment of this specimen was received by the Geological Survey in March, 1908.

A well preserved skull, without the mandible, of *Arctotherium cfr. simum,* Cope, from Pleistocene deposits on Gold-run creek, Yukon; obtained in frozen ground at a depth of 40 feet from the surface.

In addition Dr. Raymond reports the following accessions to the collection of invertebrate fossils since July 1, 1910:—

By presentation:—

Dr. Ray S. Bassler, U. S. National Museum, Washington, D.C.—

Three specimens *Beatricea gracilis,* Ulrich. From the Lowville at Bellefonte, Penna. Acc. No. 37.

Col. C. C. Grant, Hamilton, Ontario—

Three small collections (25 specimens). From the Niagara cherts at Hamilton, Ontario, Acc. No. 6.

Mr. Elfric Drew Ingall, Buena Vista road, Rockcliffe, Ont.—

Collection of fossils from the trenches on Manor road and Buena Vista road, Rockcliffe, Ontario. Acc. No. 3.

Mr. W. C. King, Auditor General's Department, Ottawa, Ontario—

One specimen *Isotelus arenicola,* Raymond. From the Chazy at Britannia, Ont. Acc. No. 1.

Mr. C. E. Oliver, Hedley, B.C., through Mr. Charles Camsell—

Four imperfect specimens of a large *Prionocyclus* from the Cretaceous on Mamloos creek, a tributary of Roche river, Similkameen district, B.C. Acc. No. 38.

Mr. Stewart Macroe, West Selkirk, Manitoba—

Eight specimens Ordovician fossils from the drift at York Factory. Acc. No. 22.

Mr. A. McNeill, Department Interior, Ottawa, Ontario—

Two fossiliferous nodules from Green creek, near Ottawa, Ontario. Acc. No. 20.

Mr. W. J. Wilson, Ottawa, Ontario—

One specimen *Isotelus gigas,* Dekay. From the Trenton at Hull, Quebec. Acc. No. 7.

By purchase:—

Rev. J. M. Goodwillie, Metcalfe, Ont.—

A collection of invertebrate fossils, principally Ordovician, Silurian, and Devonian, from various localities. About 4,000 specimens. Acc. No. 8.

Mr. George Noel, 33 Ottame St., Hull, Quebec—

About 30 specimens of invertebrate fossils from the Trenton at Hull, Quebec. Acc. No. 11.

Collected by officers of the Survey:—

Cairnes, D. D.—

Five specimens from the Cretaceous at Bee mountain, Atlin district, B.C. Acc. No. 35.

Camsell, Charles—

One fossiliferous fragment of Carboniferous rock found loose on Eagle creek, Tulameen district, B.C. Acc. No. 41.

Dowling, D. B.—

Small collection of Jurassic fossils from The Gate, Fiddle creek, Alberta. Acc. No. 24.

Dresser, J. A., and Raymond, P. E.—

About 25 specimens lower Cambrian fossils in pebbles of a conglomerate at St. Philippe de Neri, Kamouraska county, Quebec. Acc. No. 17.

Fossiliferous pebble of Trenton age from gravel on shore at St. Denis, Kamouraska county, Quebec. Acc. No. 18.

Ingall, Elfric Drew, and Raymond, P. E.—

Small collection fossils from the Beekmantown, Chazy, Lowville and Black River, at Rockland, Ontario. Acc. No. 14.

Small collection fossils from the Lowville and Chazy at Aylmer, Quebec. Acc. No. 15.

Small collection fossils from the Lorraine at Hawthorne, Ontario. Acc. No. 16.

Johnston, W. A.—

One specimen *Ormoceras allumettense* (Billings), and one of *Stromatocerium rugosum*, Hall, from the Black River in Orillia North tp., Ont. Acc. No. 42.

Keele, J.—

One specimen *Scaphites* from the Cretaceous at Seaby siding, 2 miles east of Kananaskis, Alberta. Acc. No. 12.

Leach, W. W.—

Seven specimens fossils supposed to be from the Cretaceous, from the Bulkley river, B.C. Acc. No. 34.

McInnes, W.—

Seven specimens Ordovician fossils, 1 from Pelican lake, 2 from Bigstone lake, and 4 from Deschambault lake; 3 specimens Silurian fossils from Cumberland lake; all in Saskatchewan. Acc. No. 19.

Raymond, P. E.—

Fourteen lots of fossils from the Chazy, Lowville, Black River, Trenton, and Utica, in the vicinity of Ottawa. Acc. Nos. 4, 5, 9, 10, 13, 23, 25, 31, 32, 33, 36, 39, 40, 44.

Three lots of fossils from the Beekmantown and Chazy at and near Grenville, Quebec. Acc. Nos. 26, 27, 43.

Two lots fossils from the Chazy at Quebec Junction, and Bordeaux, Quebec. Acc. Nos. 28, 29.

Six fossils from the Chazy and Lowville at Point Claire, Island of Montreal, Quebec. Acc. No. 30.

Wilson, W. J.—

Four slabs with fossils from north of Coal Mine point, Joggins Mines, N.S. Acc. No. 21.

INVERTEBRATE PALÆONTOLOGY.

(P. E. Raymond.)

Since I joined the staff on July 1 of the present year, the greater portion of my time has been spent in becoming familiar with the collections of invertebrate fossils, and selecting a series of specimens for exhibition in the new museum. In connexion with this work about 1,200 new identification labels were prepared in order to make the naming of the species conform to the modern nomenclature.

Early in October three days were spent with Mr. Dresser, collecting fossils from the conglomerates in Kamouraska county, Quebec, and late in the same month, and early in November, several days were spent in studying the stratigraphy and collecting the fossils of the Chazy formation at Aylmer, Ottawa, Grenville, Quebec Junction, Bordeaux, and Point Claire. These latter studies are still incomplete, but enough facts have been obtained to show that the lower 125 feet of the Chazy formation in the Ottawa valley, as defined in the Geology of Canada, 1863, is of upper Chazy age, while the black and buff limestones above belong to the Black River group.

The following collections have been examined and reported upon:—

Mr. Charles Camsell—

A few Carboniferous fossils found in a loose fragment on Eagle creek, Tulameen district, B.C.

Mr. D. B. Dowling—

A few specimens from the Jurassic at The Gate, Fiddle creek, Alberta.

Mr. J. A. Dresser—

Lower Cambrian fossils from the conglomerates at St. Philippe de Neri, Kamouraska county, Quebec.

Mr. W. McInnes—

A small collection from the Ordovician and Silurian, at a number of localities in Saskatchewan.

Mr. W. J. Wilson—

A few species from the Carboniferous at the Joggins mines, N.S.

PALÆONTOLOGICAL WORK IN SOUTHERN NEW BRUNSWICK.

(*W. J. Wilson.*)

In continuation of the work done in southern New Brunswick during the summers of 1908 and 1909, a few weeks, in 1910, were spent in the Grand Lake coal basin, Sunbury county, collecting fossil plants at the Minto coal mines. A short time was occupied in examining the rocks along the shore at Mispec and Cape Spencer, St. John county, where plant remains had been said to occur. Part of a week was occupied examining the rocks at Tidnish head, Nova Scotia, and a portion of Sir W. E. Logan's section at the Joggins shore, N.S. From all of these places collections were made where fossils could be found.

I am again indebted to Dr. G. F. Matthew for information about the rocks at Mispec and Cape Spencer; to Mr. Wm. McIntosh, curator of the Museum of the Natural History Society of New Brunswick, for the opportunity of examining type specimens of fossil plants; to Mr. W. B. Evans, manager of the Rothwell Coal Co., Limited, Minto, for some good specimens of fossil plants donated to the Museum, and for much valuable assistance in collecting; and to Mr. Bruce Barnes of the Northfield Coal Co., Limited, and the officers of the King Lumber Co., both of Minto, for valuable assistance in collecting from their mines.

Most of the time was spent at Minto, and adjacent mines, where a collection of about 1,000 specimens was made. The plant remains were found in the dumps of shale from the mines. The most prolific fossiliferous beds lie above the coal, and extend upward 10 or 15 feet, but in most cases only a foot or two of shale is removed with the coal, so that the best fossils rarely come to the surface. The shale is a fine-grained, dark grey rock, which when first removed, is firm and solid, but when exposed to the air and sun at once begins to crack, and in a short time disintegrates and crumbles to a fine powder. On this account the shale containing fossils has to be collected and carefully wrapped up as soon as it is thrown out, or else it falls to pieces and the fossils are lost. Some specimens can only be preserved by coating them with oil or shellac. Many of the fossils obtained at Minto will make good museum specimens, while all will be useful for study and comparison. The following are some of the genera and species collected at this locality:—

Neuropteris scheuchzeri, Hoffman (*N. hirsuta,* Lesqx).

Single leaves beautifully preserved are numerous at the King Lumber Co.'s mine. 'A well known fern marking a definite horizon of upper Carboniferous rocks.'[1]

Lepidophyllum cf. *brevifolium,* Lesq.

Detached leaflets are common in all the mines. They are supposed to be part of the fruit of *Lepidodendra,* and are arranged around a common axis, forming a cone-shaped body. A part of one of these cones was found showing the Sporangia and attached leaflets. The latter are triangular, short, pointed, and from half to three-fourths of an inch long. They are attached to the cone by a triangular base much smaller than the leaflet. These leaflets closely resemble *L. brevifolium* figured by Lesquereux,[2] only they are larger, and the sides of the triangle are usually straight instead of concave as in the figure referred to. Zeiller, in speaking of leaf-

[1] Fossil Plants, Seward. Vol. I, p. 45.

[2] The Geology of Pennsylvania by H. D. Rogers, p. 876. Plate XVII, fig. 6.

lets of *L. lanceolatum*, says: 'They are found most often isolated, but sometimes attached in greater or less numbers about a common axis, although no complete cone has been found.[1] This is also an upper Carboniferous form. Several species of *Sphenopteris* were found, one closely resembling *S. latifolia*, Brongn, and may be *S. latior* of Dawson, occurs in well-preserved fronds at the seven different mines from which collections were made. *Pecopteris* is represented by several species, and is common. *Sphenophyllum schlotheimii*, Brongn, is common, and *S. emarginatum* occurs less frequently. *Cordaites borassifolia*, Brongn, very common but usually in fragments. It is hard to get a complete leaf. *Alethopteris lonchitica*, and probably one more species, are common at the Rothwell Coal Co.'s mine, and occasionally met with at the other mines. *Stigmaria*, with rootlets attached, was found at the Gibbons mine. *Lepidodendra* occur at some of the mines in well preserved specimens, apparently of different species. Specimens of *Lepidophloios, Sigillaria, Cyclopteris, annularia,* and *equisetum* were occasionally found. Fruits are fairly common, especially one resembling *Cardiocarpum bisectum*, Dawson. At the Rothwell Coal Co.'s mine a large fruiting frond closely allied to *Antholithes rhabdocarpi*, Dawson, occurs on a slab with fronds of *Alethopteris.*

The above species were noted in the field and are only provisionally determined, as there has been no opportunity to study the collection in detail.

The shore at Cape Spencer and Mispec, in St. John county, was examined, since it was thought desirable to determine if there were any fossils in the rocks exposed there, but a somewhat careful search revealed none. It may be said, however, that owing to the rough and precipitous character of the cliffs, considerable stretches of the shore were inaccessible on foot, and consequently were not examined.

A day was spent examining the rocks along the shore at Tidnish head and vicinity, Nova Scotia, to see if there were any indications of plant remains in the coarse red sandstone. None, however, were seen in the small area traversed.

It has been suggested to the writer that a systematic collection of fossil plants should be made from the Joggins section, by examining each bed and noting the contained fossils. Such a collection would show the characteristic forms and vertical range of the plants in this great section, and would furnish criteria for the palæobotanical classification of the Coal Measures of the Joggins and adjacent basins, and help in the elucidation of the collections of fossil plants made from the rocks along the New Brunswick shore. In order to see if such a collection could be made, if opportunity offered in the near future, two days were occupied at the Joggins comparing Sir W. E. Logan's section with the beds as now exposed on the shore. Although over sixty years have elapsed since the section was made, during which time considerable changes have taken place through erosion, it was possible to correlate the beds as they now are with the printed section, and it seems quite practicable to use Logan's section for marking the specimens from each bed, thereby saving the time required in making new measurements.

While at the Joggins shore a few specimens of *Lepidodendra, Lepidophloios, Sigillaria, Alethopteris lonchitica, Antholithes,* and *Lepidostrobus* were collected. A number of reptilian remains were secured from the stump of an erect Sigillaria, and are in Mr. Lambe's hands for future study. From a carbonaceous bed on the shore a number of invertebrates were obtained. These were submitted to Dr. Percy E. Raymond, who reports several specimens of each of the following species: *Naiadites carbonarius*, Dawson, *Naiadites elongatus*, Dawson, *Spirorbis carbonarius*, and a number of undetermined ostracods.

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[1] Elements of Palæobotanique, p. 187.

NATURAL HISTORY DIVISION.

(John Macoun.)

During the past office season, while special ornithological work occupied my time, Mr. James M. Macoun, my assistant, devoted his time chiefly to the classification and systematic arrangement of the various collections which had accumulated. This botanical work was nearly completed when he left for Hudson bay early in July. The material collected on Vancouver island was worked over by Mr. C. H. Young and myself, and with the assistance of American and Canadian specialists, many of the specimens were taxidermically prepared, identified, and arranged according to their respective orders, and the new species determined. Dr. Dall, of the Smithsonian Institution, Washington, D.C., to whom over fifty species of shells were sent, reported that seventeen of them are new to science, and many others new to the Vancouver Island fauna; he also mentioned that the fauna on the outer coast of Vancouver island indicated warmer water than that of the Gulf of Georgia. Mr. Frank F. Collins, of Malden, Mass., who is writing a report on the seaweeds, makes the same statement.

Our collections of the marine fauna of the Atlantic coast being inadequate, and there being a demand for a separate catalogue of the flora of the Maritime Provinces, I was instructed to make collections during the summer in Nova Scotia, and from its coast waters.

On May 10, Mr. C. H. Young and I left Ottawa and proceeded to Yarmouth, N.S., where we commenced work on May 14. Mr. Young was instructed to make his collections chiefly from the sea, while I worked on land. Specimens were gathered principally along the south coast. A month was spent at Yarmouth, six weeks at Barrington Passage and vicinity, and the remainder of Mr. Young's time on the islands off the mouth of Lahave river. My collections were mostly made in the neighbourhood of Yarmouth, Barrington Passage, Bridgewater, Springhill, in the Annapolis valley, and at Digby.

Mr. Young obtained many fine marine specimens, a very large part of the series of animal life being gathered in the waters of the Atlantic coast of Nova Scotia; while my own collections covered the whole botanical field. For a partial list of our collections see column III, in the schedule attached.

In the beginning of November, 1909, Mr. W. Spreadborough was re-engaged, and instructed to proceed to the Biological Station at Nanaimo, Vancouver island, B.C., and collect sea birds and marine animals generally. His collection from Departure bay is large and valuable. See column I of the appended lists.

Early in the summer of 1910, Mr. Spreadborough was further instructed to proceed to Skidegate, Queen Charlotte islands, B.C., to gather natural history specimens of all kinds. He remained at work two and a half months, and made extensive collections, both on land and sea. See column II. A collection of plants was made, which is of great value, for no plants have been received from Queen Charlotte islands since Dr. Dawson's investigations in 1878.

Mr. Young's time since his return has been constantly occupied in packing, sorting and preserving the numerous specimens collected by himself and by Mr. Spreadborough during the past season.

Since my return from the field, I have been occupied writing on the flora of the Maritime Provinces: Dr. A. H. MacKay, Superintendent of Education, Nova Scotia; Dr. G. U. Hay, of St. John, New Brunswick, and Mr. Lawrence Watson, of Charlottetown, Prince Edward Island, are assisting me in every possible way.

LIST OF SPECIMENS COLLECTED.

	Departure bay, B.C.	Skidegate. Queen Charlotte islands.	Yarmouth, N.S. Barrington Passage, N.S. Lahave islands, N.S.
	I	II	III
Mammals	26	8	13
Birds	289	34	24
Birds' eggs		7	45
Nests			11
Sea turtle			1
Shells	340	2,000	4,950
Insects			500
Fishes		200	35
Sea spiders		1	4
Lobsters			5
Crabs and shrimps	19	165	65
Hermit-crabs		20	35
Isopods		20	180
Sponges	4	45	25
Barnacles		10	10
Starfishes	90	165	45
Sea worms		225	40
Sea slugs		75	4
Hydrozoa		40	13
Jelly fishes		3	
Tunicates and ascidians		95	125
Corals		45	20
Wasp's-nest			1
Breast-bones of seabirds	80		
Snakes			15
Toads and lizards			5
Sea-urchins		15	65

During the winter and spring of 1909-10, Mr. J. M. Macoun worked over a very large series of plants, and before he left for Hudson bay in July, he had nearly all the old collections, together with the herbarium, about ready for removal to the new museum. The number of sheets mounted last winter, and placed in the herbarium was 2,473. None have been mounted this autumn. The number of specimens distributed to museums was 5,303. This increase in the number of specimens available for distribution was caused by the older collections being worked over. Only 626 sheets are recorded as having been received during 1909; but there are at least 2,000 specimens in bundles which remain unopened. As usual, correspondents send specimens to be named, and 814 of these were examined for various persons in all the provinces of the Dominion. The correspondence has increased very largely this year owing to the fact that the scope of our work has widened. Miss Stewart, who keeps the record, reports 792 letters between November 25, 1909, and the same date in 1910.

New forms were collected both on the Atlantic and Pacific coasts during the past season, and specialists are now at work on some of the orders. Dr. W. H. Dall, of the Smithsonian Institution, Washington, D.C., U.S.A., reports that we have five new species of shells this year.

One feature of Mr. C. H. Young's work this year deserves special mention. We had been told that cod subsisted largely on small shell fish, but Mr. Young has disproved this notion, for he discovered that their food consists largely of hermit crabs and large shell-fish; while the haddock subsists almost exclusively on small shell-fish.

No less than 48 species of shells were obtained from haddock stomachs. Seventy species, in all, were found living on the Lahave banks.

Additions to the Museum Collections, 1909.

By purchase:—

Smith, Cecil, Quathewski cove, B.C.—
Cougar (*Felis couguar,* Kerr), March 15, 1909.

Morehouse, Avery, Zealand station, N.B.—
Two deer heads (deadlock), (*Odocoileus americanus,* Ex.) from near Woodstock, N.B., 1907.

Auston, A. R., Carcross, Yukon—
Fannin's Mountain Sheep (*Ovis Fanninii*), Dec., 1909.

Groh, Herbert, Experimental Farm, Ottawa—
Virginia Rail (*Rallus virginianus*) caught near Britannia, Ont., April 23, 1910.

Porter, H. E., Whitehorse, Yukon—
Bull, cow, and calf of Osborn's Caribou (*Rangiferrosbornii*) from Lake Arkell, Y.T.

Ewe and lamb of Dall's Mountain Sheep (*Ovis dalli,* Allen) from Arkell, Y.T.
Columbia Mountain Goat (*Oreamnos montanus columbianus,* Allen) from Arkell, Y.T.

Stimpson, J., Banff, Alta.—
Big-horn Mountain Sheep (lamb) (*Ovis cervina,* Des.), April, 1910.

Allen, E. C., Yarmouth, N.S.—
Skua (*Megalestris skua*), N. Yarmouth, N.S., March, 1910.

By presentation:—

Saunders, W. E., London, Ont.—
Pilot snake (*Coluber obsoletus,* Say.), Point Pelee, Ont., Nov. 29, 1909.

Speechly, Dr. H. M., Pilot Mound, Man.—
Nest of Ruby-throated Hummingbird (*Trochilus colubris*), Feb. 5, 1910.

Dowling, D. B., Geological Survey, Ottawa—
Trout (*Salvelinus stagnalis,* Fab. = *Salmo hoodii,* Rich.) from north branch Brazeau river behind Nikanassin range, August, 1909.

Experimental Farm, Brandon, Man.—
Bull and cow of Yak (*Bos grunniens*), March 1 and 15, 1910. Both died at Experimental Farm.

Hinton, D. W., Duncan creek, Yukon—
Flying Squirrel (*Scuiropterus yukonensis,* Osgood) from south side of Mayo lake, Y.T., April, 1910.

Criddle, Norman, Treesbank, Man.—
Nest and four eggs of Orange-crowned Warbler (*Helminthophila celata*), June 15, 1910.

Allen, John A., Geological Survey, Ottawa—

Beaver cutting on *Aspen* from Beaverfoot valley, Leanchoil, B.C., August, 1910.

Grant, Lady, Ottawa—

Tarantula's nest from California.

Thorburn, Mrs. J., Ottawa—

Venus's Flower Basket (*Euplectalla*), from Cuba.

FLORA AND FAUNA OF WEST COAST OF HUDSON BAY.

(*J. M. Macoun.*)

Pursuant to instructions I left Ottawa June 30 and joined the steamer *Stanley* at Halifax July 2, the Deputy Minister of Marine and Fisheries having kindly offered to convey me to Churchill on that boat. We reached Churchill July 25, and after engaging one man, I pitched my tent near the Hudsons' Bay Company's post, 4 miles south of the Royal Northwest Mounted Police detachment. Before leaving North Sydney I arranged with the captain of the schooner *Jeanie* that, with the permission of the officer commanding at Churchill, I should go north on that vessel from Churchill to Wager inlet. The *Jeanie* was chartered to transport police supplies and the portable houses which were to be erected at several points along the coast. This arrangement gave me exceptional facilities for studying and collecting specimens of the flora and fauna of the coast north of Churchill, that being the object of my visit to Hudson bay.

The *Jeanie* reached Churchill in due course, and I went on board and was ready to sail August 23. During the month spent in the vicinity of Churchill my camp was moved from place to place for convenience of working, and a very complete collection of plants was made. Small mammals and birds were also collected, but the latter were moulting at that time, and only skins for purposes of identification were secured. Although the Geological Survey has in its herbarium a few plants from Churchill, they had never been studied as a whole, and I was greatly surprised to find no indications there of an arctic flora. Since my return the whole collection has been gone over. It does not include a single species that can be called arctic, while in the same latitude, on the east side of Hudson bay, and indeed as far south as Big river, many truly arctic species are found. The flora at Churchill is made up of plants found farther south, the only difference between the flora of Churchill and of York being that fewer species are found at Churchill. In natural history the most interesting fact noted at Churchill this year was the absence of field mice and lemmings, usually so abundant there. It is known that an epidemic similar to that which attacks hares also destroys the smaller rodents, and my notes this year will serve as a basis for future observations. Dr. T. N. Marcellus, to whom I gave my traps at Churchill, has consented to report on this subject next year.

Houses were erected at Eskimo point, and Rankin inlet, as we went north, and I had two days for collecting at each place. We also touched at Daly bay. Two days were spent at Fullerton as we went north, two as we came south, and nine days at Wager inlet. Large collections were made at each place, and very full notes taken. The Eskimo also furnished me with valuable information relative to the habits and distribution of birds and mammals. While the flora at Churchill included no arctic species, that of Wager inlet was essentially arctic. The collections made at intermediate points show the intermingling of the arctic with the more southern flora, and we can now indicate the northern and southern limits of many species on the west coast of Hudson bay about which nothing was known previously. This I consider the most important part of my work from a scientific point of view, and the same facts, in my opinion, show conclusively that there are no cold currents striking the west coast of Hudson bay. The flora changes from south to north, just as we would expect it to change as higher latitudes are reached. This is not the case on the east side of the bay, where, as I have said, the flora indicates low summer temperatures as far south as James bay.

We were ready to leave Wager inlet on September 8, but a strong wind blowing into the harbour in which we were anchored made it impossible to get out. The wind was stronger the next day, and one anchor chain broke at 5 p.m., the second one giving way at 10.30. We were then about half a mile from the shore, but the vessel was safely beached, and at daylight when the tide was low we walked ashore. As we expected to reach Churchill at a date when bad weather might be expected, Capt. Bartlett had asked me to have all my baggage placed on board, and the collections made at Churchill were also with me. These were landed at Wager inlet without damage, but as the boats were heavily laden when we started south from Wager inlet, rock specimens and the marine material had to be left there. The tank containing these specimens was the only thing on board that could be used to carry fresh water in the boats, and its contents would have had to be left in any case, on that account. A week was consumed at Wager inlet in repairing the boats, and it was not until September 16 that we started for Fullerton, reaching there without incident on the 19th. The whaling schooner, *A. T. Gifford*, Capt. Geo. Comer, had gone into winter quarters the previous day, but Supt. C. Starnes, who had gone north to Fullerton on the *Jeanie*, arranged with Capt. Comer for transport to Churchill, and we were landed there September 25.

As at that late date there was no chance of getting out from the bay by water there was nothing to do but wait until winter travel was possible. Quarters were given me by the police detachment, and for the first month I employed myself in collecting such birds as could be procured. As soon as there was sufficient snow I left Churchill with two hunters who were going up the North river, and for two weeks had a permanent camp about 15 miles up North river, 35 miles from Churchill. From this camp I covered the whole country within walking distance, and from obseravtions made at this place, and during shorter trips up the creeks running into Churchill river, I can report that there is a considerable quantity of good spruce on all these rivers and creeks, and also along Button bay. There will be difficulty in transporting this timber to Churchill, but it is there, of good size and quality, and in considerable quantity.

The caribou were very abundant this year, the food supply for men and dogs for the whole winter being secured before December 1. Wolves were very numerous, coming into the settlement, although deer were so plentiful. Three caribou, of which I made specimens, were left at the camp referred to, but are to be brought out to Churchhill during the winter.

No attempt to cultivate even vegetables is now made at Churchill, but formerly turnips, potatoes, etc., were grown successfully. A few cattle were also kept. Dried potatoes and canned milk and butter now supply the needs of the natives. There is good pasture in the summer, but hay grass is not plentiful.

During the time I was on the schooner *Jeanie* attempts to catch fish were made nearly every day but without success. The crew was made up of Newfoundland fishermen, and during the passage through Hudson strait and across Hudson bay similar attempts had been made, but no fish were caught. There is an abundance of fish at Churchill for local needs in the summer season, the first whitefish (*Coregonus Artedi*) being taken about June 25. From that date until near the end of July they increase in numbers, growing scarcer after that time until the ice begins to take along the shore. The first salmon are taken about July 1, and are plentiful only during that month, disappearing about August 15. A few capelin are caught early in the season, and during our passage through the bay in July many of these fish were seen in brackish pools on the floating ice.

The Churchill river last summer opened in midchannel on June 11, and remained open. It closed December 5. The first boats from York Factory reached Churchill July 6.

The usual time for leaving Churchill for Split lake is November 24, and at that time I was ready to start with two men. The weather was still comparatively warm,

however, and the Churchill river open. The freezing across of the river is considered the earliest date at which inland streams and swamps can be crossed, and it was not until December 5 that a start could be made, heavy snow storms and comparatively mild weather causing the delay. From Churchill to Split lake I travelled in company with Mr. Bachand and his party. From Split lake to Gimli I was either with him or the crew of the wrecked *Jeanie,* one dog train carrying my specimens and supplies. The specimens weighed about 200 pounds, just the amount that can be carried in excess of dog feed by one train. I arrived in Winnipeg January 16, and left the same day for Ottawa, reaching here January 18.

ANTHROPOLOGICAL DIVISION.

I.

Report of Field Work, Sept.-Dec., 1910.

(E. Sapir.)

The plan of the anthropological division of the Geological Survey includes field work among the native tribes of Canada for the purpose of gathering extensive and reliable information on their ethnology and linguistics; archæological field work; publication of results obtained in these investigations; and exhibitions in the museum of specimens illustrative of Indian life and thought. All of these lines of work are important, but perhaps none is so pressing as that first mentioned.

It is planned to make an ethnological and linguistic survey of several of the tribes of Canada. A beginning was made in the fall of 1910, among the Nootka Indians of the west coast of Vancouver island. The ethnology and linguistics of the northwest coast are comparatively well known through the researches of Boas, Swanton, and others; within this area, however, the Nootka have been but little studied.

The time spent in actual work among these Indians was from Sept. 20, to Dec. 6, 1910. Owing to the fact that the complexity of Nootka life and thought makes it difficult to get an adequate idea of the tribe—or rather, group of tribes—by visiting many villages within a short time, it was decided to concentrate work on one point of the Nootka territory. For this purpose the Nootka Indians living in the neighbourhood of Alberni, B.C., were selected. They embrace two tribes, the Tsishya'ath and the Hopach'as'ath, the former claiming the Broken Group islands of Barkley sound as their original home, while the latter were localized in the region of Somass river and Sproat and Great Central lakes. Though these two tribes have intermarried to a great extent, and carry on their ceremonies in common, each still keeps up its tribal individuality.

A good deal of time was spent on the Nootka language, one of considerable phonetic difficulty and complexity of structure. The linguistic work comprised not only direct inquiries into grammatical form, but also, and indeed mainly, collection of mythological and ethnological texts. These were taken down in strictly phonetic form and were then carefully interpreted word for word, supplementary grammatical material being often obtained in connexion with text forms. It is believed that such texts are valuable not only from a linguistic standpoint, as they illustrate native speech in actual idiomatic use, but also from a strictly ethnological standpoint, expressing, as they do, the native point of view in matters of custom and belief. The most valuable of the texts are a long and rather detailed legend of the chief's family of the Ts'ishya'ath, beginning with the creation of man and the deluge and ending with the recent genealogy of the present chief, and an equally long origin myth of the wolf ritual or Tlokwana, the most important religious ceremonial of the Nootka Indians. As one of the results of the linguistic inquiry may be noted the amassing of new data bearing on the problem of the linguistic relationship of Kwakiutl and Nootka.

The ethnological work consisted in collecting data on various topics of importance; witnessing several ceremonies that were performed during the time spent in the field; and collecting museum specimens: in connexion with the two latter further ethnological data were collected. Among the topics that were investigated with some detail are the native geography of Barkley sound and Alberni canal, personal names, inheritance of family privileges, secret rituals for the attainment of power in hunting and fishing, the wolf ritual, the ts'ayeq or doctoring ritual, and

potlatches. A set of 67 songs was taken down on the phonograph. These were sung by various Indians, and include different types of songs, among them songs for success in whaling, lullabies, potlatch songs, announcement songs, gambling songs, wolf ritual songs, doctoring ritual songs, and others. The songs have been put into the hands of Mr. J. D. Sapir for transcription into notes. Among the ceremonies witnessed were four girl's puberty rituals, all of which ceremonies offered distinct traits of interest; a potlatch to which the Ho'ai'ath Indians of Numukamis bay had been invited; and the wolf ritual, which lasted eight days. The whole of the last ceremony was seen and careful notes taken; during part of its performance I was the only white man allowed to be present. A large number of face paintings used in the wolf ritual was secured from one of the older Indians; they are done in crayon colours.

The museum specimens obtained are not very many in number (upwards of 90) but illustrate many sides of the material and ceremonial life of the Nootkas. They embrace such objects as whaling harpoons and lanyards, whaling spear, sea-lion harpoons and lanyards, fish spear, native boxes, club of bone of whale, cedar-bark shredders, fish clubbers, bows, cedar-bark garments and ornaments, deerskin leggings and moccasins, snowshoes, wedges, ear and nose ornaments, masks, ceremonial whistles, and others. Leggings, moccasins, and snowshoes, all of which were peculiar to the Hopatc'as'ath, practically an inland tribe, have not yet, so far as known, been observed in ethnological literature as found among any of the Nootka tribes.

It is believed that a satisfactory beginning was made of a scientific study of the Nootka Indians. So rich and complex is the field, however, that several years of field work are necessary before anything like a complete account of these Indians can be presented.

II.

Work Among the Arctic Eskimos.

Letters from V. Stefansson, who for several years has been living with the Eskimos of the Arctic, engaged in anthropological studies for the American Museum of Natural History and the Canadian Geological Survey, were received before the close of the year. The last one, under date of April 26, was carried from Cape Lyon by an Eskimo. Mr. Stefansson was then on his way to Coronation gulf. He reports a hard and unfortunate winter. On account of the failure of the hunt, he and his Eskimo companions were at times forced to subsist on snowshoe lashings, skins, and bed-skins. During one period of privation, the Eskimos consumed all of the mammalian zoölogical specimens that had been collected. Parts of the outfit had to be abandoned, but all records and instruments were preserved. Dr. Anderson and one Eskimo had pneumonia, and ten of the eighteen dogs died. At the time of writing, a good game country had been reached, and no further trouble with regard to food was anticipated. Regarding plans for the summer, he writes:—

'We expect to spend the summer with the Coronation Gulf Eskimos, if we find them, and may try to visit Southern Victorialand, if we learn it is inhabited. No systematic mapping of the coast will be tried, for we find Dr. Richardson's work satisfactory in general. He is not to blame for "River la Ronciere," which clearly is non-existent. We have spent a month hunting caribou in its supposed delta and have travelled by sled every mile of coast from the tip of Cape Bathurst to the tip of Cape Parry (as well as most of that distance by skin boats, etc., in summer), and can testify that no stream over 20 miles long other than Horton river (of Franklin's second journey) enters the sea between the two capes.

'The unlikeliness of the delivery of this letter to you causes me to make it brief. I will only add that both Dr. R. M. Anderson and myself hope to get home in the autumn of 1911; we shall then have been three and a half years on the present undertaking.'

MAPPING AND ENGRAVING DIVISION.

(C.-Omer Senécal.)

The personnel of the mapping and engraving division is at present composed of a chief officer, nine draughtsmen, and a clerk. Towards the close of the year 1910 competitive examinations of draughtsmen were held by the Civil Service Commission in order to fill vacancies created by the resignation of two members of the staff, the writer, in company with two officers of the Department of the Interior, acting as examiners. First-class draughtsmen were selected, and it is expected that shortly the staff will be considerably reinforced.

As in former years, the work assigned to this division consisted mainly in the compilation and drawing of original maps and diagrams of all kinds to illustrate geological memoirs, their preparation for reproduction by various processes, their revision for publications, etc., and general geographical work.

Three hundred and eighty-five letters, memoranda, specification sheets, reports, etc., relating to the work of this division, were sent out; while 351 were received.

The meetings of the Geographic Board of Canada were regularly attended by the writer, and place-names appearing on Geological Survey maps were as usual submitted for approval. Lists of approved names are published in the Annual Report of the Board, and from time to time in the *Canada Gazette*. The writer has been appointed on the Executive Committee for the year 1911.

The following 13 maps and drawings are at present in various stages of progress in the hands of the King's Printer. Several editions are expected to be issued within a very short time:—

Victoria Topographical sheet, British Columbia series.
Saanich Topographical sheet, British Columbia series.
Lardeau, B.C., Topographical map.
Phœnix, B.C., Topographical map.
Phœnix, B.C., Geological map.
Jasper Park, Alta., Relief topographical sketch.
Jasper Park, Alta., Stereogram of sections.
Thetford-Black Lake Mining district, Quebec.
Lake Timiskaming mining region, Quebec.
Millstream iron ore deposit, New Brunswick.
Nipisiguit iron ore deposit, New Brunswick.
Province of Nova Scotia, general geography.
Kingsport Geological sheet, No. 84 N. S. series.

There are also several page-size illustrations for memoirs in the printer's hands.

A list of the maps, diagrams, etc., published during the past year, is appended herewith.

List of Map Editions received from the King's Printer during the Year, 1910.

Series A.	Publication Number.	Title.	Number of Accompanying Memoir.	Remarks.
......	1042	Dominion of Canada Scale, 100 miles to 1 inch	....	Minerals. 3rd edition.
......	1084	" " — " "	....	Geology. 2nd edition.
10	1103	Yukon Territory Tantalus coal area. Scale, 2 miles to 1 inch	5	Areal geology.
11	1104	" " —Braeburn, Kynocks coal area. Scale, 2 miles to 1 inch	5	" "
1	1095	British Columbia—Hedley map. Scale, 1,000 feet to 1 inch	2	Topography.
2	1096	" " Hedley map. Scale, 1,000 feet to 1 inch	2	Geology.
3	1106	" " —Hedley. Mineral claims on Henry creek. Scale, 800 feet to 1 inch	2	Areal geology.
4	1105	" " —Hedley. Golden Zone mining camp. Scale, 600 feet to 1 inch	2	Economic geology.
......	1125	" " —Hedley. Structure sections. Scale, 1,000 feet to 1 inch	2	Geology.
.....	1126	" " —Hedley. Natural section, Nickel Plate mountain. Scale, 450 feet to 1 inch	2	Economic geology.
...	1127	" " —Hedley. Section, No. 3 Tunnel, Nickel Plate mine. Scale, 100 feet to 1 inch	2	" "
......	1128	" " —Hedley. Section running N 70° E, across Nickel Plate mountain. Scale, 450 feet to 1 inch	2	" "
.....	1129	" " —Hedley. Section, No. 4 Tunnel, Nickel Plate mine. Scale, 200 feet to 1 inch	2	" "
......	....	" " —Sheep Creek mining camp, West Kootenay. Scale, 1 mile to 1 inch	......	Sketch geological map.
...	....	" " —Deadwood mining area. Scale, 400 feet to 1 inch	....	Topography. Advance edition.
......	1099	North West Territories Pelly, Ross, and Gravel rivers. Scale, 8 miles to 1 inch	....	Exploratory.
5	1117	Alberta—Edmonton map. Scale, $\frac{1}{4}$ mile to 1 inch	8	Topography.
6	1118	" —Edmonton map. Scale, $\frac{1}{2}$ mile to 1 inch	8	Economic geology.
7	1132	" —Bighorn Coal Basin. Scale, 2 miles to 1 inch	9	Geological reconnaissance.
....	1145	" —Bighorn Coal Basin. Birdseye view	9	" "
9	1089	North West Territories and Ontario Albany, Severn, and Winisk rivers. Scale, 8 miles to 1 inch	....	Exploratory.
......	993	Northwestern Ontario Country traversed by National Transcontinental railway, between Lake Nipigon and Sturgeon lake. Scale, 4 miles to 1 inch	....	" 2nd edition.
8	1090	" " —Lake Nipigon map. Scale, 4 miles to 1 inch	1	"
12	1112	Quebec Country traversed by National Transcontinental railway in Abitibi district. Scale, 4 miles to 1 inch	......	Areal geology. Exploratory.
......	1078	" —St. Bruno map. Scale, 800 feet to 1 inch	....	Topography.
..	1079	" — " "	....	Geology.
14	1134	Nova Scotia Hall harbour. Sheet No. 99, Kings county. Scale, 1 mile to 1 inch	....	Areal geology.
		Also 11 zinc cut diagrams and illustrations for various reports.		

LIBRARY.

(J. Alexander, Acting Librarian.)

During the calendar year, 3,152 publications were received as gifts or exchanges, including—besides periodicals—maps, reports, and publications of foreign Geological Surveys, together with memoirs, transactions, and proceedings of scientific societies.

149 volumes were purchased, costing $534.62, with 400 Gaylord pamphlet binders at a cost of $26.65.

352 volumes were bound, and 88 periodicals were subscribed for.

202 letters relating to the work of the library were sent out, with 696 acknowledgments of publications received as gifts.

In addition to the current cataloguing work, about 1,500 cards have been rewritten and brought up to date.

PUBLICATIONS.

The following Reports have been Published since January 1, 1910.

No.

1006. Report on a Traverse through the Southern part of the North West Territories, from Lac Seul to Cat lake, 1902. By A. W. G. Wilson. Published January 10, 1911. } Bound together.

1080. Report on a Part of the North West Territories drained by the Winisk and Upper Attawapiskat rivers. By W. McInnes. Published January 10, 1911.

1059. Report on a Geological Reconnaissance of the Region traversed by the National Transcontinental railway, between Lake Nipigon and Clay lake, Ont. By W. H. Collins. Published February 18, 1910.

1077. Memoir No. 7: On Geology of St. Bruno mountain. By J. A. Dresser. Published June 24, 1910.

1082. Memoir No. 6: On the Geology of the Haliburton and Bancroft Areas, Ont. By F. D. Adams and A. E. Barlow. Published September 22, 1910.

1091. Memoir No. 1: On the Geology of the Nipigon basin, Ont. By A. W. G. Wilson. Published December 20, 1910.

1093. Memoir No. 2: On the Geology and Ore Deposits of Hedley Mining Camp, B.C. By Chas. Camsell. Published November 2, 1910.

1097. Report on a Reconnaissance across the Mackenzie mountains on the Pelly, Ross, and Gravel rivers, Yukon and North West Territories. By Joseph Keele. Published June 24, 1910.

1101. Memoir No. 5 (Preliminary): On the Lewes and Nordenskiold Rivers Coal district, Yukon. By D. D. Cairnes. Published December 15, 1910.

1107. Report on the Geological Position and Characteristics of the Oil-shale Deposits of Canada, Part II. By R. W. Ells. Published February 24, 1910.

1109. Memoir No. 3: On Palæoniscid Fishes of Albert Shales, N.B.: being Vol. III (quarto) of Contributions to Canadian Palæontology. By Lawrence M. Lambe. Published August 17, 1910.

1115. Memoir No. 8: Preliminary Report on the Edmonton Coal fields. By D. B. Dowling. Published February 13, 1911.

1120. Summary Report, 1909. Published July 7, 1910.

1139. Memoir No. 11: On Triangulation of Vancouver island, B.C. By C. H. Chapman. Published November 25, 1910.

1141. Memoir No. 12-P: Contributions to Canadian Palæontology, Vol. II, Part iii. Canadian Fossil Insects. By Anton Handlirsch. (5) Insects from the Tertiary Lake deposits of the southern interior of British Columbia, collected by Mr. Lawrence M. Lambe, in 1906. Published January 30, 1911.

1143. Memoir No. 14: Description of Shells collected by John Macoun at Barkley sound, Vancouver island, B.C. By Messrs. W. H. Dall and Paul Bartsch. Published January 16, 1911.

1144. Reprint of J. A. Dresser's Preliminary Report on the Serpentine Belt of Southern Quebec: being pages 180-199 of Geological Survey Summary Report, 1909. Published July 27, 1910.

1146. Notes on Canada. By R. W. Brock. Published August 4, 1910.

SPECIAL REPRINTS.

(I.) Bibliography of Canadian Zoology for 1907, by Lawrence M. Lambe. Transactions of the Royal Society of Canada, Vol. II, 3rd series, 1908-9 (1909).

(II.) The Nepheline and Associated Alkali Syenites of Eastern Ontario, by Frank D. Adams and Alfred E. Barlow. Transactions of the Royal Society of Canada, Vol. II, 3rd series, 1908-9 (1909). Published April 21, 1910.

New Contributions to Canadian Bryology, by N. Conr. Kindberg, Ph.D., Upsala, Sweden. The Ottawa Naturalist, Vol. XXIII, November, 1909, and January, 1910.

Description of a New Species of Ammonite, of the Genus Stepheoceras, from some rocks presumably Jurassic age, in the Nicola valley, B.C., by Dr. J. F. Whiteaves. The Ottawa Naturalist, May, 1909.

Appendices A. and C. of MacMillan's Arctic Explorations—
A.—Palæontology, by Lawrence M. Lambe.
B.—Botany, by James M. Macoun.
Published February 2, 1911.

On Two New Trilobites from the Chazy near Ottawa, by Percy E. Raymond. The Ottawa Naturalist, November, 1910. Published November 28, 1910.

Note on the Parietal Crest of Centrosaurus Afertus, and on a Proposed New Generic name for Stereocephalus Tulus, by Lawrence M. Lambe. The Ottawa Naturalist, December, 1910. Published January 10, 1911.

FRENCH TRANSLATIONS.

(*M. Sauvalle.*)

No.

999. Preliminary report on Gowganda Mining Division, District of Nipissing, Ont. By W. H. Collins. Published August 24, 1910.

1035*a*. Coal Fields of Manitoba, Saskatchewan, Alberta, and Eastern British Columbia. By D. B. Dowling. Published March 17, 1911.

1038. Report on the Transcontinental Railway location between Lake Nipigon and Sturgeon lake. By W. H. Collins. Published January 27, 1910.

1069. Report on Exploration of East Coast of Hudson bay. By A. P. Low. Published April 20, 1910.

1072. Summary Report, 1908. Published January 17, 1911.

1086. A Descriptive Sketch of the Geology and Economic Minerals of Canada. By G. A. Young: with Introductory by R. W. Brock. Published June 16, 1910.

1114. Report on a Geological Reconnaissance of a Portion of Algoma and Thunder Bay districts. By W. J. Wilson. Published September 13, 1910. } Bound together.

1119. Report on the Region lying north of Lake Superior, between the Pic and Nipigon rivers, Ont. By W. H. Collins. Published September 13, 1910. }

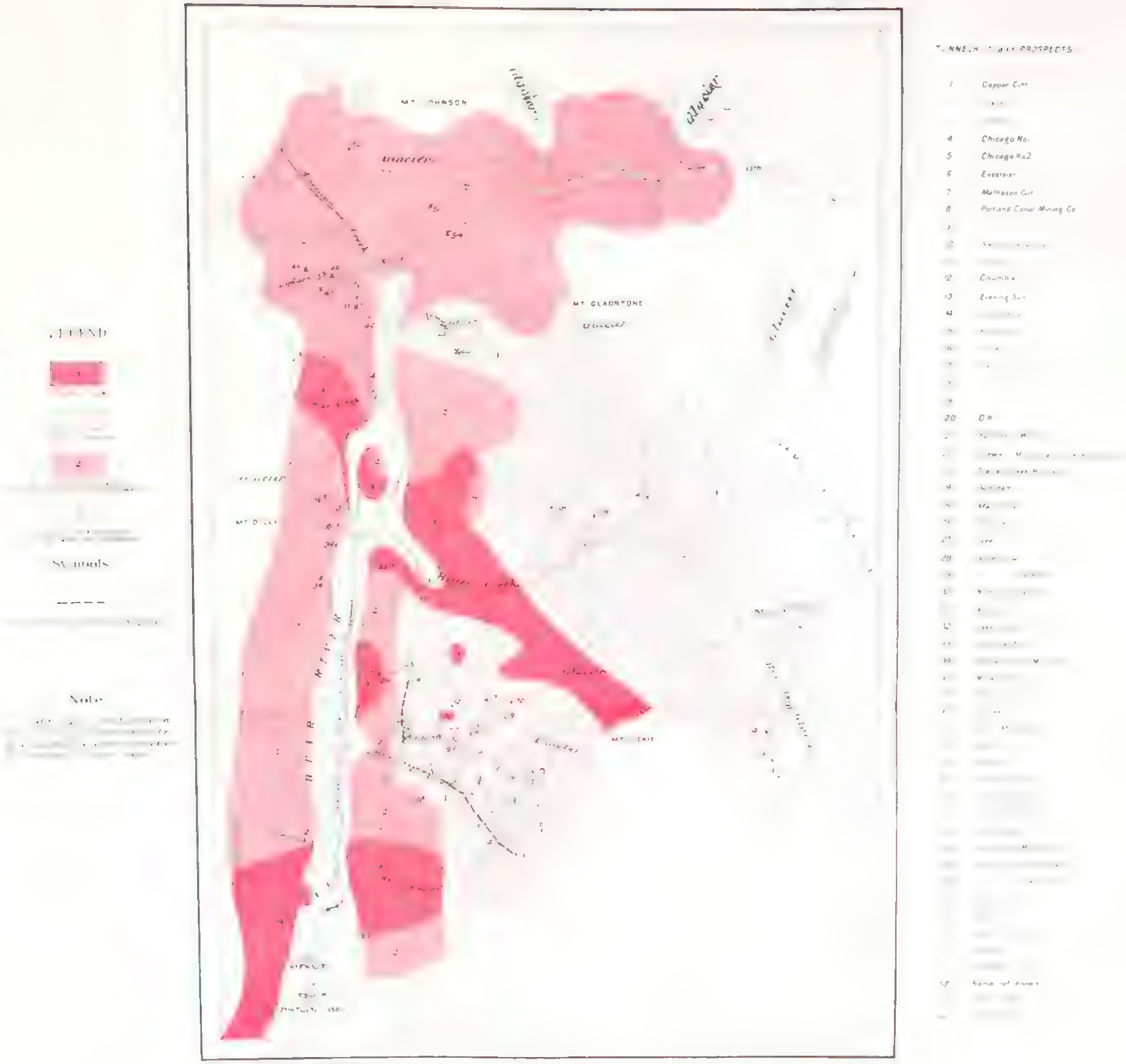
Canada

Department of Mines

Geological Survey

Hon. W. Templeman, Minister; A. P. Low, Deputy Minister

BRITISH COLUMBIA



Sketch Map of

PORTLAND CANAL MINING DISTRICT

BRITISH COLUMBIA

Scale of Miles

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(I.)

(II.)

New

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Appe

On

Note

No.
999.

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ACCOUNTANT'S STATEMENT.

The staff of the Geological Survey at present employed numbers 72. During the calendar year the following changes have taken place:—

Appointments—

P. E. Raymond, E. Sapir, S. G. Alexander, J. J. Carr, C. A. McDonald.

Resignations—

J. F. E. Johnston, O. O'Sullivan, F. O'Farrell.

The funds available for the work, and the expenditure of the Geological Survey for the fiscal year ending March 31, 1910, were:—

Details.	Grant.	Expenditure.
Appropriations	$349,956 50	
Civil list salaries		$100,766 34
Explorations and surveys		81,413 23
Experimental borings for gas, oil, etc.		25,282 00
Printing, engraving, and lithographing		31,540 43
Books and instruments		5,228 80
Specimens for Museum		5,471 54
Stationery, mapping materials, etc.		4,785 02
Wages of temporary employes		677 19
Incidental and other expenses		8,031 60
Unexpended balance		86,759 75
	$349,956 50	$349,956 50

(Signed) JNO. MARSHALL,
Accountant.

All of which is respectfully submitted.

I have the honour to be,
Sir,
Your obedient servant,

(Signed) R. W. BROCK.

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CANADA

DEPARTMENT OF MINES

GEOLOGICAL SURVEY BRANCH

Hon. W. Templeman, Minister; A. P. Low, Deputy Minister; R. W. Brock, Director.

SELECTED LIST OF REPORTS AND MAPS

(SINCE 1885)

OF SPECIAL ECONOMIC INTEREST

PUBLISHED BY

THE GEOLOGICAL SURVEY.

Report of the Mines Section:—

No. 245.	Report of Mines Section, 1886.	No. 662.	Report of Mines Section, 1897.
272	" " 1887.	698	" " 1898.
*300	" " 1888.	718	" " 1899.
301	" " 1889.	744	" " 1900.
334	" " 1890.	800	" " 1901.
335	" " 1891.	835	" " 1902.
360	" " 1892.	893	" " 1903.
572	" " 1893-4.	*928	" " 1904.
602	" " 1895.	971	" " 1905.
625	" " 1896.		

Mineral Production of Canada:—

No. *414.	Year 1886.	No. *422.	Year 1893.	No. 719.	Year 1900.
*415	" 1887.	*555	" 1894	719a	" 1901.
*416	" 1888.	*577	" 1895	813	" 1902.
*417	" 1889.	*612	" 1896.	861	" 1903.
*418	" 1890.	*623	" 1886–96	896	" 1904.
*419	" 1891.	*640	" 1897.	924	" 1905.
*420	" 1886–91	*671	" 1898.	981	" 1906.
*421	" 1892.	*686	" 1899.		

Mineral Resources Bulletin:—

No. *818.	Platinum.	No. 860.	Zinc.	No. 881.	Phosphate.
851.	Coal.	869.	Mica.	882.	Copper.
*854.	Asbestos.	872.	Molybdenum and Tungsten.	913.	Mineral Pigments.
857.	Infusorial Earth.	*877.	Graphite.	953.	Barytes.
858.	Manganese.	880.	Peat.	984.	Mineral Pigments (French).
859	Salt.				

Report of the Section of Chemistry and Mineralogy:—

No. *102.	Year 1874–5.	No. *169.	Year 1882–3–4.	No. 580.	Year 1894.
*110	" 1875–6.	222.	" 1885.	616	" 1895.
*119	" 1876–7.	246	" 1886.	651	" 1896.
*126	" 1877–8.	273	" 1887–8.	695	" 1898.
*138	" 1878–9.	299	" 1888–8.	724	" 1899.
*148	" 1879–80.	333	" 1890–1.	821	" 1900.
*156	" 1880–1–2.	359	" 1892–3.	*958	" 1906.

*Publications marked thus are out of print.

REPORTS.

GENERAL.

745. Altitudes of Canada, by J. White. 1899.
*972. Descriptive Catalogue of Minerals and Rocks, by R. A. A. Johnston and G. A. Young.
1073. Catalogue of Publications: Reports and Maps (1843-1909).
1085. Descriptive Sketch of the Geology and Economic Minerals of Canada, by G. A. Young, and Introductory by R. W. Brock. Maps No. 1084; No. 1042 (second edition), scale 100 m. = 1 in.
1086. French translation of Descriptive Sketch of the Geology and Economic Minerals of Canada, by G. A. Young, and Introductory by R. W. Brock. Maps No. 1084; No. 1042 (second edition), scale 100 m. =1 in.
1107. Part II. Geological position and character of the oil-shale deposits of Canada, by R. W. Ells.
1146. Notes on Canada, by R. W. Brock.

YUKON.

*260. Yukon district, by G. M. Dawson. 1887. Maps No. 274, scale 60 m. =1 in.; Nos. 275 and 277, scale 8 m=1 in.
*295. Yukon and Mackenzie basins, by R. G. McConnell. 1889. Map No. 304, scale 48 m. =1 in.
687. Klondike gold fields (preliminary), by R. G. McConnell. 1900. Map No. 688, scale 2 m. =1 in.
884. Klondike gold fields, by R. G. McConnell. 1901. Map No. 772, scale 2 m. = 1 in.
*909. Windy Arm, Tagish lake, by R. G. McConnell. 1906. Map No. 916, scale 2 m. =1 in.
943. Upper Stewart river, by J. Keele. Map No. 938, scale 8 m. =1 in.
951. Peel and Wind rivers, by Chas. Camsell. Map No. 942, scale 8 m. =1 in.
} Bound together.
979. Klondike gravels, by R. G. McConnell. Map No. 1011, scale 40 ch. =1 in.
982. Conrad and Whitehorse mining districts, by D. D. Cairnes. 1901. Map No. 990, scale 2 m. =1 in.
1016. Klondike Creek and Hill gravels, by R. G. McConnell. (French.) Map No. 1011, scale 40 ch. =1 in.
1050. Whitehorse Copper Belt, by R. G. McConnell. Maps Nos. 1,026, 1,041, 1,044-1,049.
1097. Reconnaissance across the Mackenzie mountains on the Pelly, Ross, and Gravel rivers, Yukon, and North West Territories, by Joseph Keele. Map No. 1099, scale 8 m. =1 in.
1011. Memoir No. 5 (Preliminary) : on the Lewes and Nordenskiöld Rivers coal field, Yukon, by D. D. Cairnes. Maps Nos. 1103 and 1104, scale 2 m. = 1 in.

BRITISH COLUMBIA.

212. The Rocky mountains (between latitudes 49° and 51° 30′), by G. M. Dawson. 1885. Map No. 223, scale 6 m. =1 in. Map No. 224, scale 1½ m. =1 in.
*235. Vancouver island, by G. M. Dawson. 1886. Map No. 247, scale 8 m. = 1 in.
236. The Rocky mountains, geological structure, by R. G. McConnell. 1886. Map No. 248, scale 2 m. =1 in.
263. Cariboo mining district, by A. Bowman. 1887. Maps Nos. 278-281.
*271. Mineral wealth, by G. M. Dawson.
*294. West Kootenay district, by G. M. Dawson. 1888-9. Map No. 303, scale 8 m. =1 in.
*573. Kamloops district, by G. M. Dawson. 1894. Maps Nos. 556 and 557, scale 4 m. =1 in.
574. Finlay and Omineca rivers, by R. G. McConnell. 1894. Map No. 567 scale 8 m. =1 in.

* Publications marked thus are out of print.

743. Atlin Lake mining division, by J. C. Gwillim. 1899. Map No. 742, scale 4 m. = 1 in.
939. Rossland district, by R. W. Brock. Map No. 941, scale 1,600 ft. = 1 in.
*940. Graham island, by R. W. Ells. 1905. Maps No. 921, scale 4 m. = 1 in; No. 922, scale 1 m. = 1 in.
986. Similkameen district, by Chas. Camsell. Map No. 987, scale 400 ch. = 1 in.
988. Telkwa river and vicinity, by W. W. Leach. Map No. 989, scale 2 m. = 1 in.
996. Nanaimo and New Westminster districts, by O. E. LeRoy. 1907. Map No. 997, scale 4 m. = 1 in.
1035. Coal-fields of Manitoba, Saskatchewan, Alberta, and Eastern British Columbia, by D. B. Dowling.
1093. Geology, and Ore Deposits of Hedley Mining district, British Columbia, by Charles Camsell. Maps Nos. 1095 and 1096, scale 1,000 ft. = 1 in.; No. 1105, scale 600 ft. = 1 in.; No. 1106, scale 800 ft. = 1 in.; No. 1125, scale 1,000 ft. = 1 in.

ALBERTA.

*237. Central portion, by J. B. Tyrrell. 1886. Maps Nos. 249 and 250, scale 8 m. = 1 in.
324. Peace and Athabaska Rivers district, by R. G. McConnell. 1890-1. Map No. 336, scale 48 m. = 1 in.
703. Yellowhead Pass route, by J. McEvoy. 1898. Map No. 676, scale 8 m. = 1 in.
*949. Cascade coal-fields, by D. B. Dowling. Maps (8 sheets) Nos. 929-936, scale 1 m. = 1 in.
968. Moose Mountain district, by D. D. Cairnes. Maps No. 963, scale 2 m. = 1 in.; No. 966, scale 1 m. = 1 in.
1035. Coal-fields of Manitoba, Saskatchewan, Alberta, and Eastern British Columbia, by D. B. Dowling. Map No. 1010, scale 35 m. = 1 in.
1035a. French translation of coal-fields of Manitoba, Saskatchewan, Alberta, and Eastern British Columbia, by D. B. Dowling. Map No. 1010, scale 35 m. = 1 in.
1115. Memoir No. 8-E: Edmonton coal-field, by D. B. Dowling. Maps Nos. 1117–5A and 1118–6A, scale 2640 ft. = 1 in.

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213. Cypress hills and Wood mountain, by R. G. McConnell. 1885. Maps Nos. 225 and 226, scale 8 m. = 1 in.
601. Country between Athabaska lake and Churchill river, by J. B. Tyrrell and D. B. Dowling. 1895. Map No. 957, scale 25 m. = 1 in.
868. Souris River coal-field, by D. B. Dowling. 1902.
1035. Coal-fields of Manitoba, Saskatchewan, Alberta, and Eastern British Columbia, by D. B. Dowling. Map No. 1010, scale 35 m. = 1 in.

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264. Duck and Riding mountains, by J. B. Tyrrell. 1887-8. Map No. 282, scale 8 m. = 1 in.
296. Glacial Lake Agassiz, by W. Upham. 1889. Maps Nos. 314, 315, 316.
325. Northwestern portion, by J. B. Tyrrell. 1890-1. Maps Nos. 339 and 350, scale 8 m. = 1 in.
704. Lake Winnipeg (west shore), by D. B. Dowling. 1898. Map No. 664, scale 8 m. = 1 in. } Bound together.
705. Lake Winnipeg (east shore), by J. B. Tyrrell. 1898. Map No. 664, scale 8 m. = 1 in.
1035. Coal-fields of Manitoba, Saskatchewan, Alberta, and Eastern British Columbia, by D. B. Dowling. Map No. 1010, scale 35 m. = 1 in.

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217. Hudson bay and strait, by R. Bell. 1885. Map No. 229, scale 4 m. = 1 in.
238. Hudson bay, south of, by A. P. Low. 1886.
239. Attawapiskat and Albany rivers, by R. Bell. 1886.

*Publications marked thus are out of print.

244. Northern portion of the Dominion, by G. M. Dawson. 1886. Map No. 255, scale 200 m. = 1 in.
267. James bay and country east of Hudson bay, by A. P. Low.
578. Red lake and part of Berens river, by D. B. Dowling. 1894. Map No. 576, scale 8 m. = 1 in.
*584. Labrador peninsula, by A. P. Low. 1895. Maps Nos. 585-588, scale 25 m. = 1 in.
618. Dubawnt, Kazan, and Ferguson rivers, by J. B. Tyrrell. 1896. Map No. 603, scale 25 m. = 1 in.
657. Northern portion of the Labrador peninsula, by A. P. Low.
680. South Shore Hudson strait and Ungava bay, by A. P. Low. Map No. 699, scale 25 m. = 1 in.
713. North Shore Hudson strait and Ungava bay, by R. Bell. Map No. 699, scale 25 m. = 1 in.
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725. Great Bear lake to Great Slave lake, by J. M. Bell. 1900.
778. East Coast Hudson bay, by A. P. Low. 1900. Maps Nos. 779, 780, 781, scale 8 m. = 1 in.
786–787. Grass River region, by J. B. Tyrrell and D. B. Dowling. 1900.
815. Ekwan river and Sutton lakes, by D. B. Dowling. 1901. Map No. 751, scale 50 m. = 1 in.
819. Nastapoka islands, Hudson bay, by A. P. Low. 1900.
905. The Cruise of the *Neptune*, by A. P. Low. 1905.
1006. Report of a Traverse through the Southern Part of the North West Territories, from Lac Seul to Cat lake, 1902, by A. W. G. Wilson.
1080. Report on a Part of the North West Territories, drained by the Winisk and Upper Attawapiskat rivers, by W. McInnes. Map No. 1089, scale 8 m. = 1 in.
(1006 and 1080: Bound together.)
1069. French translation report on an exploration of the East coast of Hudson bay, from Cape Wolstenholme to the south end of James bay, by A. P. Low. Maps Nos. 779, 780, 781, scale 8 m. = 1 in.; No. 785, scale 50 m. = 1 in.
1097. Reconnaissance across the Mackenzie mountains on the Pelly, Ross, and Gravel rivers, Yukon, and North West Territories, by Joseph Keele. Map No. 1099, scale 8 m. = 1 in.

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215. Lake of the Woods region, by A. C. Lawson. 1885. Map No. 227, scale 2 m. = 1 in.
*265. Rainy Lake region, by A. C. Lawson. 1887. Map No. 283, scale 4 m. = 1 in.
266. Lake Superior, mines and mining, by E. D. Ingall. 1888. Maps No. 285, scale 4 m. = 1 in.; No. 286, scale 20 ch. = 1 in.
326. Sudbury mining district, by R. Bell. 1890-1. Map No. 343, scale 4 m. = 1 in.
327. Hunter island, by W. H. C. Smith. 1890-1. Map No. 342, scale 4 m. = 1 in.
332. Natural Gas and Petroleum, by H. P. H. Brumell. 1890-1. Maps Nos. 344-349.
357. Victoria, Peterborough, and Hastings counties, by F. D. Adams. 1892-3.
627. On the French River sheet, by R. Bell. 1896. Map No. 570, scale 4 m. = 1 in.
678. Seine river and Lake Shebandowan map-sheets, by W. McInnes. 1897. Maps Nos. 589 and 560, scale 4 m. = 1 in.
723. Iron deposits along the Kingston and Pembroke railway, by E. D. Ingall. 1900. Map No. 626, scale 2 m. = 1 in.; and plans of 13 mines.
*739. Carleton, Russell, and Prescott counties, by R. W. Ells. 1899. (*See* No. 739, Quebec.)
741. Ottawa and vicinity, by R. W. Ells. 1900.
790. Perth sheet, by R. W. Ells. 1900. Map No. 789, scale 4 m. = 1 in.
961. Sudbury Nickel and Copper deposits, by A. E. Barlow. (Reprint.) Maps Nos. 775, 820, scale 1 m. = 1 in.; Nos. 824, 825, 864, scale 400 ft. = 1 in.
962. Nipissing and Timiskaming map-sheets, by A. E. Barlow. (Reprint.) Maps Nos. 599, 606, scale 4 m. = 1 in.; No. 944, scale 1 m. = 1 in.

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*Publications marked thus are out of print.

965. Sudbury Nickel and Copper deposits, by A. E. Barlow. (French.)
970. Report on Niagara Falls, by J. W. Spencer. Maps Nos. 926, 967.
977. Report on Pembroke sheet, by R. W. Ells. Map No. 660, scale 4 m. = 1 in.
980. Geological reconnaissance of a portion of Algoma and Thunder Bay district, Ont., by W. J. Wilson. Map No. 964, scale 8 m. = 1 in. } Bound together.
1081. On the region lying north of Lake Superior, between the Pic and Nipigon rivers, Ont., by W. H. Collins. Map No. 964, scale 8 m. = 1 in. } Bound together.
992. Report on Northwestern Ontario, traversed by National Transcontinental railway, between Lake Nipigon and Sturgeon lake, by W. H. Collins. Map No. 993, scale 4 m. = 1 in.
998. Report on Pembroke sheet, by R. W. Ells. (French.) Map No. 660, scale 4 m. = 1 in.
999. French translation Gowganda Mining Division, by W. H. Collins. Map No. 1076, scale 1 m. = 1 in.
1038. French translation report on the Transcontinental Railway location between Lake Nipigon and Sturgeon lake, by W. H. Collins. Map No. 993, scale 4 m. = 1 in.
1059. Geological reconnaissance of the region traversed by the National Transcontinental railway between Lake Nipigon and Clay lake, Ont., by W. H. Collins. Map No. 993, scale 4 m. = 1 in.
1075. Gowganda Mining Division, by W. H. Collins. Map No. 1076, scale 1 m. = 1 in.
1082. Memoir No. 6 : Geology of the Haliburton and Bancroft areas, Ont , by Frank D. Adams and Alfred E. Barlow. Maps No. 708, scale 4 m. = 1 in.; No. 770, scale 2 m. = 1 in.
1091. Memoir No. 1: On the Geology of the Nipigon basin, Ont., by A. W. G. Wilson. Map No. 1090, scale 4 m. = 1 in.
1114. French translation: Geological reconnaissance of a portion of Algoma and Thunder Bay district, Ont., by W. J. Wilson. Map No. 964, scale 8 m. = 1 in. } Bound together.
1119. French translation: On the region lying north of Lake Superior, between the Pic and Nipigon rivers, Ont., by W. H. Collins. Map No. 964, scale 8 m. = 1 in. } Bound together.

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240. Compton, Stanstead, Beauce, Richmond, and Wolfe counties, by R. W. Ells. 1886. Map No. 251 (Sherbrooke sheet), scale 4 m. = 1 in.
268. Megantic, Beauce, Dorchester, Levis, Bellechasse, and Montmagny counties, by R. W. Ells. 1887-8. Map No. 287, scale 40 ch. = 1 in.
297. Mineral resources, by R. W. Ells. 1889.
328. Portneuf, Quebec, and Montmagny counties, by A. P. Low. 1890-1.
579. Eastern Townships, Montreal sheet, by R. W. Ells and F. D. Adams. 1894. Map No. 571, scale 4 m. = 1 in.
591. Laurentian area north of the Island of Montreal, by F. D. Adams. 1895. Map No. 590, scale 4 m. = 1 in.
670. Auriferous deposits, southeastern portion, by R. Chalmers. 1895. Map No. 667, scale 8 m. = 1 in.
707. Eastern Townships, Three Rivers sheet, by R. W. Ells. 1898.
*739. Argenteuil, Ottawa, and Pontiac counties, by R. W. Ells. 1899. (*See* No. 739, Ontario).
788. Nottaway basin, by R. Bell. 1900. *Map No. 702, scale 10 m. = 1 in.
863. Wells on Island of Montreal, by F. D. Adams. 1901. Maps Nos. 874, 875, 876.
923. Chibougamau region, by A. P. Low. 1905.
962. Timiskaming map-sheet, by A. E. Barlow. (Reprint). Maps Nos. 599, 606, scale 4 m. = 1 in.; No. 944, scale 1 m. = 1 in.
974. Report on Copper-bearing rocks of Eastern Townships, by J. A. Dresser. Map No. 976, scale 8 m. = 1 in.
975. Report on Copper-bearing rocks of Eastern Townships, by J. A. Dresser. (French).
998. Report on the Pembroke sheet, by R. W. Ells. (French).
1028. Report on a Recent Discovery of Gold near Lake Megantic, Que., by J. A. Dresser. Map No. 1029, scale 2 m. = 1 in.

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*Publications marked thus are out of print.

1032. Report on a Recent Discovery of Gold near Lake Megantic, Que., by J. A. Dresser. (French). Map No. 1029, scale 2 m. = 1 in.
1052. French translation report on Artesian wells in the Island of Montreal, by Frank D. Adams and O. E. LeRoy. Maps Nos. 874, scale 4 m. = 1 in.; No. 375, scale 3,000 ft. = 1 in.; No. 876.
1144. Reprint of Summary Report on the Serpentine Belt of Southern Quebec, by J. A. Dresser.

NEW BRUNSWICK.

218. Western New Brunswick and Eastern Nova Scotia, by R. W. Ells. 1885. Map No. 230, scale 4 m. = 1 in.
219. Carleton and Victoria counties, by L. W. Bailey. 1885. Map No. 231, scale 4 m. = 1 in.
242. Victoria, Restigouche, and Northumberland counties, N.B., by L. W. Bailey and W. McInnes. 1886. Map No. 254, scale 4 m. = 1 in.
269. Northern portion and adjacent areas, by L. W. Bailey and W. McInnes. 1887–8. Map No. 290, scale 4 m. = 1 in.
330. Temiscouata and Rimouski counties, by L. W. Bailey and W. McInnes. 1890–1. Map No. 350, scale 4 m. = 1 in.
661. Mineral resources, by L. W. Bailey. 1897. Map No. 675, scale 10 m. = 1 in. New Brunswick geology, by R. W. Ells. 1887.
799. Carboniferous system, by L. W. Bailey. 1900. } Bound together.
803. Coal prospects in, by H. S. Poole. 1900. }
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1034. Mineral resources, by R. W. Ells. (French). Map No. 969, scale 16 m. = 1 in.

NOVA SCOTIA.

243. Guysborough, Antigonish, Pictou, Colchester, and Halifax counties, by Hugh Fletcher and E. R. Faribault. 1886.
331. Pictou and Colchester counties, by H. Fletcher. 1890–1.
358. Southwestern Nova Scotia (preliminary), by L. W. Bailey. 1892–3. Map No. 362, scale 8 m. = 1 in.
628. Southwestern Nova Scotia, by L. W. Bailey. 1896. Map No. 641, scale 8 m. = 1 in.
685. Sydney coal-field, by H. Fletcher. Maps Nos. 652, 653, 654, scale 1 m. = 1 in.
797. Cambrian rocks of Cape Breton, by G. F. Matthew. 1900
871. Pictou coal-field, by H. S. Poole. 1902. Map No. 833, scale 25 ch. = 1 in.

MAPS.

1042. Dominion of Canada. Minerals. Scale 100 m. = 1 in.

YUKON.

*805. Explorations on Macmillan, Upper Pelly, and Stewart rivers, scale 8 m. = 1 in.
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894. Sketch Map Kluane Mining district, scale 6 m. = 1 in.
*916. Windy Arm Mining district, Sketch Geological Map, scale 2 m. = 1 in.
990. Conrad and Whitehorse Mining districts, scale 2 m. = 1 in.
991. Tantalus and Five Fingers coal mines, scale 1 m. = 1 in.
1011. Bonanza and Hunker creeks. Auriferous gravels. Scale 40 chains = 1 in.
1033. Lower Lake Laberge and vicinity, scale 1 m. = 1 in.
1041. Whitehorse Copper belt, scale 1 m. = 1 in.
1026. 1044–1049. Whitehorse Copper belt. Details.
1099. Pelly, Ross, and Gravel rivers, Yukon and North West Territories. Scale 8 m. = 1 in.
1103. Tantalus Coal area, Yukon. Scale 2 m. = 1 in.
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